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FOR

1909.

(INCORPORATED 1881.)

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1910.

NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. × $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

ERRATA.

Page 342, for "Yass-Canberra," read *Monaro*.
Plate XII, for "Taema," read *Taemas*.

PUBLICATIONS.

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The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

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I bequeath the sum of £ to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

NOTICE.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

Corrected Address:

Name..

....

Titles, &c...

....

Address..

....

....

Date..........................

To the

Hon. Secretaries,

The Royal Society of N. S. Wales,

5 Elizabeth Street, Sydney.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch M., 16 College-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1877	P 5	Abbott, W. E., 'Abbotsford,' Wingen.
1895		Adams, J. H. M., Broughton Cottage, St. James' Rd., Waverley.
1904		Adams, William John, M. I. Mech. E., 175 Clarence-street.
1906		Adams, Walter E., Assistant Engineer, Sydney Harboür Trust, Circular Quay.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ld., Cement Works, Granville.
1905		Anderson, Charles, M.A., D. Sc., *Edin.*, Park Avenue, Burwood.
1909	P 1	Andrews, E. C., B.A., Geological Surveyor, Department of Mines, Sydney.
1903		Arnot, Arthur James, Assoc. M. Inst. C.E., M. I. Mech. E., M.I.E.E., Electrical Engineer, 83 Pitt-street.
1878		Backhouse, Alfred P., M.A., District Court Judge, 'Melita,' Elizabeth Bay.
1894	P 14	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1896		Barff, H. E., M.A., Registrar, Sydney University.
1908	P 1	Barling, John, 'St. Adrians,' Raglan-street, Mosman.
1895	P 9	Barraclough, S. Henry, B.E., M.M.E., Assoc M. Inst C E, M. I. Mech. E, Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Lecturer in Mechanical Engineering, Sydney University; p.r. 'Marmion,' Victoria-street, Lewisham.
1906		Basnett, Nathaniel James, Accountant, Punch-st., Mosman.
1894		Baxter, William Howe, Chief Surveyor, Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1900		Bender, Ferdinand, Accountant and Auditor, 21 Elizabeth-street, North.
1909		Benson, William Noel, Junior Demonstrator in Geology, Sydney University, Glebe.
1905		Bignold, Hugh Baron, Barrister-at-Law, Chambers, Wentworth Court, 64 Elizabeth-street.
1906		Binnie, Herbert, 524 Kent-st; p.r. 'Seabright,' Woollahra Pt.

Elected		
1905		Blakemore, George Henry, Australian Club, Macquarie-street.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Fremantle, West Australia.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1898		Blunno, Michele, Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture, Sydney.
1905		Board, Peter, M.A. *Syd*, Under Secretary and Director of Education. Department of Public Instruction, Sydney.
1907		Bogenrieder, Charles, Mining and Consulting Engineer, 4 Clifton-street off Nicholson Road, Balmain.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1907		Boyd, Robert James, M.E., Assoc. M. Inst. C.E., 'Greenstead,' Park Röad, Burwood.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Ric. R. Coll. Sur. *Irel.*, 3 Lyons Terrace, Hyde Park.
1891		Brennand, Henry J. W., B.A., M.B., Ch. M. *Syd.*, F.R.A.S., F.G.S., 'Wabun,' 310 Miller-street, North Sydney.
1902		Brereton, Victor Le Gay, Solicitor, Royal Chambers, Hunter-street; p.r. 'Osgathorpe,' Gladesville.
1878		‡Brooks, Joseph, F.R A.S., F.R.G.S., 'Hope Bank,' Nelson-street, Woollahra.
1876		Brown, Henry Joseph, Solicitor, Newcastle.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Kingston,' Merrylands.
1903		Bruck, Ludwig, Medical Publisher, 15 Castlereagh-street.
1898		‡Burfitt, W. Fitzmaurice, B.A., B Sc, M.B., Ch.M *Syd.*, 357 Glebe Road, Glebe Point.
1890		Burne, Dr. Alfred, Dentist, 1 Lyons Terrace, Liverpool-street.
1907		Burrows, Thomas Edward, M Inst C E., L.S., Metropolitan Engineer, Public Works Department; p.r. 'Balboa,' Fern-street, Randwick.
1880		Bush, Thomas James, M. Inst. C E. Australian Gas-light Company, 153 Kent-street.
1909		Calvert, Thomas Copley, M. Inst C.E, 'Maybank,' Manly.
1904	P 1	Cambage, Richard Hind, F.L.S., Chief Mining Surveyor; p.r. Park Road, Burwood.
1907		Campbell, Alfred W., Medical Practitioner, 183 Macquarie-st.
1900		Canty. M., 'Rosemont,' 13 York-street, Wynyard Square.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd., Edgecliffe.
1897	P 4	Cardew, John Haydon, M. Inst. C.E, L.S., 75 Pitt-street.
1901		Card, George William, A.R.S.M., F.G.S., Curator and Mineralogist to the Geological Survey, N.S.W., Department of Mines.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.*, F.F.A. *Scot.*, Australian Mutual Provident Society, 87 Pitt-st. *Hon. Treasurer.*
1909		Carne, Joseph Edmund, Assistant Government Geologist, Department of Mines, Sydney.
1903		Carslaw, H. S., M.A., D. Sc, Professor of Mathematics, Sydney University, Glebe.
1909		Chalmers, Nathaneal, M. Inst. C.E., L.S., Civil Engineer, 12 Hoskins' Buildings, Spring-street.

Elected		
1909		Chapman, H. G., M D., Demonstrator of Physiology, Sydney University, Glebe.
1879	P 1	‡Chard, J. S., Licensed Surveyor, Addison Road, Manly.
1908		Chauleur, Paul, Officier de l'Instruction Publique, Conseiller du Commerce Extérieur de la France; Secrétaire-Trésorier de la Chambre de Commerce française, 2 Bond-street.
1909	P 2	Cleland, John Burton, M.D., Ch. M., Principal Assistant, Microbiologist, Bureau of Microbiology, 93 Macquarie-street.
1907		Cobham, Allan Blenman, 'Garthowen,' Myahgah Rd., Mosman.
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. Inst. C.E., Water and Sewerage Board, North Sydney.
1904	P 2	Cooksey, Thomas, Ph. D., B Sc. *Lond.*, F.I.C., Second Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman,
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.R.C.P. *Edin*, Fuller's Road, Chatswood.
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1882		Cornwell, Samuel, J.P., 'Capanesk,' Shirley Rd., Wollstonecraft, North Sydney.
1909		Cotton, Leo Arthur, Linnean Macleay Fellow in Geology, Macleay Museum, Sydney University.
1892	P 1	Cowdery, George R., Assoc M. Inst. C.E., 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 16 College-street, Hyde Park.
1905		Dampney, Gerald F., F.I.C., 'Doonbah,' Hunter's Hill.
1875		Dangar, Fred. H., c/o W. E. Deucher, 12 and 14 Loftus-street.
1890		Dare, Henry Harvey, M.E., Assoc. M. Inst. C.E., Public Works, Department.
1876	P 3	Darley, Cecil West, M. Inst. C.E., Australian Club, Sydney.
1886	P 19	David, T. W. Edgeworth, B.A., F.G.S., F.R.S., Professor of Geology and Physical Geography, Sydney University, Glebe.
1909		Davidson, George Frederick, Demonstrator in Mechanical Engineering, Sydney University; p.r. 223 Bridge Road, Glebe Point.
1892	P 1	Davis, Joseph M. Inst C.E., London.
1907		Davys, Hubert John, c/o Messrs. Clutterbuck Bros. & Co., Builders' Exchange, Castlereagh-street; p.r. 'La Bohéme,' Marshall-street, Manly.
1885	P 3	Deane, Henry, M.A., M. Inst C.E., F.L.S., F. R. Met. Soc., F.R.H.S., Equitable Building, George-st.; p.r. 'Blanerne,' Wybalena Road, Hunter's Hill. *Vice-President.*
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1875	P 12	Dixon, W. A., F.C.S., F.I.C., 97 Pitt-street.
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1876		Evans, George, Fitz Evan Chambers, Castlereagh-street.
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1902		Faithfull, William Percy, Barrister-at-Law, Australian Club.
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1900		‡Flashman, James Froude, M.D. *Syd*,. Jersey Road, Burwood.
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1906		Gosche, W. A. Hamilton, Electrical Engineer, 171 Clarence-st.
1897		Gould, Senator, The Hon. Sir Albert John, 'Eynesbury,' Edgecliffe.
1907		Green, W. J., Chairman, Hetton Coal Co., Athenæum Club.
1899		Greig-Smith, R., D. Sc *Edin*, M. Sc., *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay.
1899	P 2	Gummow Frank M., M.C.E., Corner of Bond and Pitt-streets.
1891	P 15	Guthrie, Frederick B., F.I.C., F.C.S., Chemist, Department of Agriculture, 136 George-street, Sydney, *Hon. Secretary.*

Elected		
1880	P 3	Halligan, Gerald H., F.G.S.. 'Riversleigh,' Hunter's Hill.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1909		Hammond, Walter L., Science Master, Hurlstone Agricultural Continuation School, 'Rostella,' Grosvenor Crescent, Summer Hill.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; Government Analyst, Health Department, Macquarie-street North. *Vice-President.*
1905	P 1	Harker, George, D.Sc., 35 Boulevarde, Petersham.
1881		‡Harris, John, 'Bulwarra,' Jones-street, Ultimo,
1887	P 23	‡Hargrave, Lawrence, Wunulla Road, Woollahra Point.
1884	P 1	Haswell, William Aitcheson, M.A., D.Sc., F.R.S., Professor of Zoology and Comparative Anatomy, University, Sydney; p.r. 'Mimihau,' Woollahra Point.
1900		Hawkins, W. E., Solicitor, 88 Pitt-street.
1891	P 1	Hedley, Charles, F.L.S., Assistant Curator, Australian Museum, Sydney.
1900	P 3	Helms, Richard, 392 Alfred-street, North Sydney.
1899		Henderson, J., F.R.E,S., Manager, City Bank of Sydney, Pitt-st.
1899		Henderson, S., M.A., Assoc. M. Inst. C.E, Equitable Building, George-street.
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1905		Hooper, George, Assistant Superintendent, Sydney Technical College; p.r. 'Branksome,' Henson-street, Summer Hill.
1905		Hoskins, George J., M. I. Mech E., Burwood Road, Burwood.
1907		Hoskins, George Herbert, 'St. Cloud,' Burwood-rd., Burwood.
1891	P 2	Houghton, Thos. Harry, M. Inst. C.E., M. I. Mech E. 63 Pitt-street.
1906		Howle, Walter Creswell, Medical Practitioner. Bega, N.S.W.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Acting Chief Inspector of Mines, Geological Surveyor, Department of Mines.
1904	P 5	Jenkins, R. J H., 'Pyalla,' 13A Selwyn-street, Moore Park.
1905		Jensen, Harold Ingemann, D.Sc., 'Elba,' 67 Boyce-st., Glebe Pt.
1907		Johnson, T. R., M. Inst. C.E., Chief Commissioner of New South Wales Railways, Public Works Department.
1909	P 5	Johnston, Thomas Harvey, M.A., B.Sc., Assistant Government Microbiologist, Bureau of Microbiology, 93 Macquarie-st.
1902		Jones, Henry L., Assoc. Am. Soc. C.E, 14 Martin Place.
1884		‡Jones, Llewellyn Charles Russell, Solicitor, Falmouth Chambers, 117 Pitt-street.
1867		Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 16 College street, Hyde Park; p.r. 'Llandilo,' Boulevard, Strathfield.
1876	P 2	Josephson, J. Percy, Assoc. M. Inst. C.E., Stephen Court, 77 Elizabeth-street; p.r. Kallara.
1907		Kaleski, Robert, Agricultural Expert, Holdsworthy, Liverpool.
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.

Elected		
1873	P 2	Keele, Thomas William, M. Inst. C.E., Commissioner, Sydney Harbour Trust, Circular Quay; p.r. Llandaff-st., Waverley.
1906		Keenan, Rev. Bernard, D.D. etc., 'Royston,' Rose Bay
1887		Kent, Harry C., M.A., F.R.I.B.A., Bell's Chambers, 129 Pitt-st.
1901		Kidd, Hector, M. Inst. C.E., M. I. Mech. E., 'Craig Lea,' 15 Mansfield-street, Glebe Point.
1896		King, Kelso, 120 Pitt-street.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.G.S. *Irel.*, 'Wellington,' Bondi Road, Bondi.
1881	P 18	Knibbs, G. H., F.R.A.S., Member Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; Commonwealth Statistician Melbourne.
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1909		Lawrence, Richard Priestley, M. Inst. C.E., Civil Engineer, 12 Hoskin's Buildings, Spring-street.
1906		Lee, Alfred, Merchant, 'Glen Roona,' Penkivil-st., Bondi.
1909		Leverrier, Frank, B.A., B. Sc., Barrister-at-Law, 182 Phillip-st.
1883		Lingen, J. T., M.A. *Cantab.*, 167 Phillip-street.
1901		Little, Robert, 'The Hermitage,' Rose Bay.
1872	P 57	Liversidge, Archibald, M.A. *Cantab.*, LL.D., F.R.S., Hon. F.R.S. *Edin.*, Assoc. Roy. Sch, Mines, *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chem. of Gt. Brit. and Irel.; Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phys. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineralogical Society, *France*; Corr. Mem. Edin. Geol. Soc.; New York Acad. of Sciences; Roy. Soc. *Tas.*; Roy. Soc., *Queensland;* Senckenberg Institute, *Frankfurt;* Société d' Acclimat., *Mauritius;* Foreign Corr. Indiana Acad. of Sciences; Hon. Mem. Roy. Soc., *Vict.;* N.Z. Institute; K, Leop Carol. Acad., *Halle a/s;* The United University Club, Suffolk-st.. Pall Mall, London W.
1906		Loney, Charles Augustus Luxton, M. Am. Soc. Refr. E., Equitable Building, George-street.
1884		MacCormick, Alexander, M.D., C.M. *Edin.*. M.R.C.S. *Eng.*, 185 Macquarie-street, North.
1887		MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 24 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co. Ld., 2 Spring-street.
1868		MacDonnell, W. J., 4 Falmouth Chambers, 117 Pitt-st.
1903		McDonald, Robert, J.P., Under Secretary for Lands; p.r. 'Wairoa,' Holt-street, Double Bay.
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1906		McIntosh, Arthur Marshall, Dentist, 'Dalmore,' Albert Avenue, Chatswood.
1891	P 2	McKay, R. T., Assoc. M. Inst C.E., 'Shandon,' 352 Miller-street, North Sydney.
1893		McKay, William J. Stewart, B.Sc., M.B., Ch.M., Cambridge-street, Stanmore.
1876		Mackellar, The Hon. Charles Kinnaird, M.L.C., M.B., C.M. *Glas.*, Equitable Building, George-street.

Elected		
1904		McKenzie, Robert, Sanitary Inspector, (Water and Sewerage Board), 'Stonehaven Cottage.' Bronte Road, Waverley.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. Inst. C.E., Australian Club, Macquarie-street.
1903		McLaughlin, John, Solicitor, Clement's Chambers, 88 Pitt-st.
1876		MacLaurin, The Hon. Sir Henry Normand, M.L.C., M.A., M.D., L.R.C.S. *Edin.*, LL.D. *St. Andrews*, 155 Macquarie-street.
1901	P 1	McMaster, Colin J., Chief Commissioner of Western Lands; p.r. Wyuna Road, Woollahra Point.
1894		McMillan, Sir William, K.C.M.G., 'Llandudno,' Old South Head Road, Woollahra.
1899		MacTaggart, J. N. C., M.E. *Syd.*, Assoc. M. Inst. C.E., Water and Sewerage Board District Office, Lyons Road, Drummoyne.
1882	P 1	Madsen, Hans F., 'Hesselmed House,' Queen-st., Newtown.
1909		Madsen, John Percival Vissing, D.Sc., B.E., P. N. Russell Lecturer in Electrical Engineering, Sydney University.
1883	P 20	Maiden, J. Henry, J.P., F.L.S., Hon. Fellow Roy. Soc., S.A.; Hon. Memb. Nat. Hist. Soc., W.A., Netherlands Soc. for Promotion of Industry; Philadelphia College Pharm.; Southern California Academy of Sciences; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin.; Soc. Nac. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc. Tas.; Inst. Nat. Genévois; Hon. Vice-Pres. of the Forestry Society of California; Diplomé of the Société Nationale d' Acclimatation de France; Government Botanist and Director, Botanic Gardens, Sydney. *Hon Secretary.*
1906		Maitland, Louis Duncan, Dental Surgeon. 6 Lyons' Terrace Liverpool-street.
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1897		Marden, John, B.A., M.A., LL.B. *Melb.*, LL.D. *Syd.*, Principal, Presbyterian Ladies' College, Sydney.
1908		Marshall, Frank, B.D.S. *Syd.*, Dental Surgeon, 141 Elizabeth-st.
1875	P 25	Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d'Anthrop, de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor. Mem. Anthrop. Soc., Vienna; Cor. Mem. Roy. Geog. Soc. Aust.,Queensland; 'Carcuron,' Hassall-st., Parramatta.
1908		Meares, Frederick Thomas Devenish, 'Parkhurst,' Ormond-st., Ashfield.
1903		Meggitt, Loxley, Manager Co-operative Wholesale Society, Alexandria.
1905		Miller, James Edward, Walgett.
1889	P 8	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines, Government Metallurgical Works, Clyde; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Illawarra Coal Co., Gresham-street,
1877		‡Mullens, Josiah, F.R.G.S., 'Tenilba,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point.
1876		Myles, Charles Henry, 'Dingadee,' Everton Rd., Strathfield.

Elected		
1893	P 2	**Nangle, James, Architect, 'St. Elmo,' Tupper-st., Marrickville.**
1891		**‡Noble, Edwald George, Public Works Department, Newcastle.**
1893		**Noyes, Edward, ASSOC. INST. C.E., ASSOC. I. MECH. E., c/o Messrs. Noyes Bros., 109 Pitt-street.**
1903		Old, Richard, Solicitor, 'Waverton,' Bay Rd., North Sydney.
1896		Onslow, Lt. Col. James William Macarthur, Camden Park, Menangle.
1875		O'Reilly, W. W. J., M.D., M. CH., Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 129 Liverpool-street, Hyde Park.
1891		Osborn, A. F., ASSOC. M. INST. C.E., Water Supply Branch, Sydney, 'Linton,' Parkes-street, Ryde.
1883		Osborne, Ben. M., J.P., 'Hopewood,' Bowral.
1906		Oschatz, Alfred Leopold, Teacher of Languages, 46 High-st., North Sydney.
1903		Owen, Rev. Edward, B.A., All Saints' Rectory, Hunter's Hill.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 183 Liverpool-street, Hyde Park.
1906		Pawley, Charles Lewis, Dentist, 137 Regent-street.
1901		Peake, Algernon, ASSOC. M. INST. C.E., 25 Prospect Road, Ashfield.
1899		Pearse, W., Union Club; p.r. Moss Vale.
1877		Pedley, Perceval R., Australian Club.
1899		Petersen, T. Tyndall, Member of Sydney Institute of Public Accountants, Copper Mines, Burraga.
1909	P 1	Pigot, Rev. Edward F., S.J., B.A., M.B. *Univ. Dub.*, St. Ignatius College, Riverview.
1879	P 7	Pittman, Edward F., ASSOC. R.S.M., L.S., Under Secretary and Government Geologist, Department of Mines.
1896		Plummer, John, 'Northwood,' Lane Cove River; Box 413 G.P.O,
1881		Poate, Frederick, Lands Office, Moree.
1879		Pockley, Thomas F. G., Commercial Bank, Singleton.
1887	P 7	Pollock, James Arthur, B.E. Roy. Univ. *Irel.*, D.SC., *Syd.*, Professor of Physics, Sydney University.
1896		Pope, Roland James, B.A. *Syd.*, M.D., C.M., F.R.C.S. *Edin.*, Ophthalmic Surgeon, 235 Macquarie-street.
1893		Purser, Cecil, B.A., M.B., CH. M. *Syd.*, 'Valdemar,' Boulevard, Petersham.
1901	P 1	Purvis, J, G. S., Water and Sewerage Board, 341 Pitt-street.
1908		Pye, Walter George, M.A., B.SC., Nield Avenue, Paddington,
1876		Quaife, F. H., M.A., M.D., Mast. Surg. *Glas.*, 'Hughenden,' 14 Queen-street, Woollahra. *Vice-President.*
1890	P 1	**Rae, J. L. C., 'Endcliffe,' Church-street, Newcastle.**
1865	P 1	**‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S.E., F.L.S., 8 Palace-street, Petersham.**
1890		**Rennie, George E., B.A. *Syd.*, M.D. *Lond.*, M.R.C.S. *Eng.*, 159 Macquarie-street.**
1906		**Redman, Frederick G., P. and O. Co., Pitt-street.**

Elected		
1909		Rhodes, Thomas, Civil Engineer, Carlingford and Public Works Department.
1902		Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1906		Richardson, H. G. V., 15 Lombard Chambers, Pitt-street City.
1892		Rossbach, William Assoc. M. Inst. C.E., Public Works Department, Sydney.
1884		Ross, Chisholm, M.D. *Syd.*, M.B , C.M. *Edin.*, 147 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1904	P 2	Ross, William J. Clunies, B.Sc., *Lond. & Syd.*, F.G S., Lecturer in Chemistry, Technical College, Sydney.
1882		Rothe, W. H., Colonial Sugar Co., O'Connell-street, and Union Club.
1897		Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, Assoc. M. Inst. C.E., Phœnix Chambers, 158 Pitt-street.
1905		Scheidel, August, Ph. D., Managing Director, Commonwealth Portland Cement Co., Sydney; Union Club.
1899		Schmidlin, F., 39 Phillip-street, City.
1892	P 1	Schofield, James Alexander, F C.S., A.R.S.M., University, Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1877	P 4	Selfe, Norman, M. Inst. C.E., M. I. Mech. E., Victoria Chambers, 279 George-street.
1904	P 1	Sellors, R. P., B.A. *Syd.*, 'Cairnleith,' Military Road, Mosman.
1908		Sendey, Henry Franklin, Manager of the Union Bank of Australia, Ld., Sydney, Union Club.
1883	P 3	Shellshear, Walter, M. Inst. C.E., Inspecting Engineer, Existing Lines Office, Bridge-street.
1905		Simpson, D. C., M. Inst. C.E., N.S. Wales Railways, Redfern; p.r. 'Clanmarrina,' Rose Bay.
1900		Simpson, R. C., Technical College, Sydney.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. Cleveland-street, Wahroonga.
1893		Sinclair, Russell, M. I. Mech. E. etc., Vickery's Chambers, 82 Pitt-st.
1891	P 3	Smail, J. M., M. Inst. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1893	P 36	Smith, Henry G., F C.S , Assistant Curator, Technological Museum, Sydney.
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1896		Spencer, Walter, M.D. *Brux.*, Ch. D , M.R.C.S., L.R.C.P. *Eng.*, Corresponding Member, Royal College of Medicine, Chief Medical Officer Sydney Rescue Work Society; 'Milton,' Edgeware Road, Enmore. *Vice-President.*
1892	P 1	Statham, Edwyn Joseph, Assoc. M. Inst. C.E., Cumberland Heights, Parramatta.
1900		Stewart, Professor J. D., M,R.C.V.S., University of Sydney; p.r. Cowper-street, Randwick.
1903		Stoddart, Rev. A. G., The Rectory, Manly.

Elected		
1909		Stokes, Edward Sutherland, M.B. *Syd.*, R C P.S. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1883	P 4	Stuart, T. P. Anderson, M D., LL.D. *Edin*, Professor of Physiology, University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay.
1901	P 3	Süssmilch, C. A., Technical College, Sydney.
1907		Sutherland, David Alex., F I C., Equitable Building, George-st.
1906		Taylor, Allen, Lord Mayor of Sydey,'Ellerslie,' 85 Darlinghurst Road.
1906		Taylor, Horace, Registrar, Dental Board, 7 Richmond Terrace, Domain.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1893		‡Taylor, James, B. Sc., A.R.S.M., 'Adderton,' Dundas.
1899		Teece, R., F.I.A., F,F.A,, General Manager and Actuary, A.M.P. Society, 87 Pitt-street.
1861	P 19	Tebbutt, John, F R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1878		Thomas, F. J., Newcastle and Hunter River Steamship Co., 147 Sussex-street.
1879		Thomson, Hon. Dugald, M.H.R., Carabella-st., North Sydney.
1885	P 2	Thompson, John Ashburton, M D. *Brux.*, D.P.H. *Cantab.*, M,R.C.S. *Eng.*, Health Department, Macquarie-street.
1896		Thompson, Capt. A. J. Onslow, Camden Park, Menangle.
1892		Thow, William, M. Inst. C.E., M. I. Mech. E., Locomotive Department, Eveleigh.
1894		Tooth, Arthur W., Kent Brewery, 26 George-street, West.
1879		Trebeck, P. C., F. R. Met. Soc., 12 O'Connell-street.
1900		Turner, Basil W., A.R S.M., F.C.S., Victoria Chambers, 83 Pitt-st.
1883		Vause, Arthur John, M.B., C.M. *Edin*, 'Bay View House,' Tempe.
1890		Vicars, James, M.C.E., City Engineer and Surveyor, Adelaide.
1892		Vickery, George B., 78 Pitt-street.
1903	P 4	Vonwiller, Oscar U., B.Sc., Demonstrator in Physics, University of Sydney.
1876		Voss, Houlton H., J.P., Union Club, Sydney.
1907		Waley, F. G., Assoc. M. Inst. C.E, c/o Belambi Coal Co. Ltd., Bridge-street.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, Senator The Hon. J. T., 'Wallaroy,' Edgecliffe Road, Woollahra.
1901		Walkom, A. J., A.M.I.E.E., Electrical Branch, G.P.O., Sydney.
1891	P 1	Walsh, Henry Deane, B.A.I., T.C. *Dub.*, M. Inst. C.E., Engineer-in-Chief, Harbour Trust, Circular Quay. *President.*
1903		Walsh, Fred, George and Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Sydney E.
1901		Walton, R. H., F C.S., 'Flinders,' Martin's Avenue, Bondi.
1898		Wark, William, Assoc. M. Inst. C.E., 9 Macquarie Place; p.r. Kurrajong Heights.

Elected		
1883	P 16	Warren, W. H., Wh. Sc., M. Inst. C.E., M. Am. Soc. C.E., Member of Council of the International Society for Testing Materials, Professor of Engineering, University of Sydney.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman, Attorney General's Department, Macquarie-st.
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville Road, Newtown.
1908		Weatherburn, Charles Ernest, M.A., B.Sc., *Syd.*, B.A. *Cantab.*, 'Oakley,' Arthur-street, Croydon.
1897		Webb, Frederick William, C.M.G., J.P., 'Livadia,' Manly.
1903		Webb, A. C. F., M.I.E.E., Vickery's Chambers, 82 Pitt-street.
1892		Webster, James Philip, Assoc. M. Inst. C.E., L.S., *New Zealand*, Town Hall, Sydney.
1907		Weedon, Stephen Henry, C.E., 'Kurrowah,' Alexandra-street, Hunter's Hill.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, C.M.G., Head Master, Sydney Grammar School, College-street.
1907		Welch, William, F.R.G.S., 'Roto-iti,' Boyle-street, Mosman.
1881		‡Wesley, W, H.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1909		White, Charles Josiah, Science Lecturer, Sydney Training College; p.r. 'Patea,' Miller Avenue, Ashfield.
1879		‡Whitfeld, Lewis, M.A. *Syd.*, 'Sellinge,' Albert-st., Woollahra.
1907		Wiley, William, 'Kenyon,' Kurraba Point, Neutral Bay.
1876		Williams, Percy Edward, Commissioner, Government Savings Bank, Sydney.
1908		Willis, Charles Savill, M.B., Ch.M., *Syd.*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H., Roy. Coll. P. & S. *Lond.*, Department of Public Health.
1901		Willmot, Thomas, J.P., Toongabbie.
1890		Wilson, James T., M.B., Ch.M. *Edin.*, Professor of Anatomy, University of Sydney.
1907		Wilson, William Claude, Assistant Engineer, Public Works Department, Sydney.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1909		Woodhouse, William John, M.A., Professor of Greek, Sydney University, Glebe.
1906	P 3	Woolnough, Walter George, D.Sc., F.G.S., Demonstrator in Geology, University of Sydney.
1902		Wright, John Robinson, Lecturer in Art, Technical College, Harris-street, Sydney.
1909		Yeomans, Richard John, Solicitor, 14 Castlereagh-street.

Honorary Members.

Limited to Thirty.

M.—Recipients of the Clarke Medal.

1875		Bernays, Lewis A., C.M.G., F.L.S., Brisbane.
1905		Cannizzaro, Stanislao. Professor of Chemistry, Reale Università, Rome.

Elected		
1900		Crookes, Sir William, F.R.S., 7 Kensington Park Gardens, London W.
1905		Fischer, Emil, Professor of Chemistry, University, Berlin.
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., c/o Director of the Royal Gardens, Kew.
1892		Huggins, Sir William, K.C.B., D.C.L., LL.D., F.R.S., &c., 90 Upper Tulse Hill, London, S.W.
1901		Judd, J.W., C.B., LL.D., F.R.S., F.G.S., Professor of Geology, Royal College of Science, London; 30 Cumberland Road, Kew, England.
1908		Kennedy, Sir Alex. B. W., LL.D., F.R.S., 17 Victoria-street, Westminster, London S.W.
1903		Lister, Right Hon. Joseph, Lord, O.M., B.A., M.B., F.R.C.S. D.C.L., F.R.S., Hon. M. Inst. C.E., etc., 12 Park Crescent, Portland Place, London, W.
1908		Liversidge, Prof., M.A., LL.D., F.R.S., The United University Club, Suffolk-street, Pall Mall, London S.W.
1905		Oliver, Daniel, LL.D., F.R.S., Emeritus Professor of Botany, University College, London.
1894		Spencer, W. Baldwin, M.A., C.M.G., F.R.S., Professor of Biology, University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., LL.D., Sc. D., Ph. D., The Ferns, Witcombe, Gloucester, England.
1908		Turner, Sir William, K.C.B., M.B., D.C.L., LL.D., Sc. D., F.R.C.S. *Edin.*, F.R.S., 6 Eton Terrace, Edinburgh, Scotland.
1895		Wallace, Alfred Russel, D.C.L. *Oxon.*, LL.D. *Dublin*, F.R.S., Old Orchard, Broadstone, Wimborne, Dorset.

Obituary 1909.

Honorary Member.

1901		Newcomb, Professor Simon, Real-Admiral U.S. Navy.

Ordinary Members.

1876		Colyer, J. U. C.
1877		Darley, Sir Frederick.
1881		Foster, The Hon. W. J.
1892		Kirkcaldie, D.
1906		Wade, J. S.
1878		Wilshire, J. T.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The late Revd. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix indicates the decease of the recipient.

1878 *Professor Sir Richard Owen. K.C.B., F.R.S.
1879 *George Bentham, C.M.G., F.R.S.
1880 *Professor Thos. Huxley, F.R.S., The Royal School of Mines, London.
1881 *Professor F. M'Coy, F.R.S., F.G.S.
1882 *Professor James Dwight Dana, LL.D.
1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S.
1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.
1886 *Professor L. G. De Koninck, M.D., University of Liège.
1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.
1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890 *George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1893 *Professor Ralph Tate, F.L.S., F.G.S.
1895 Robert Logan Jack, F.G.S., F.R.G.S., late Government Geologist, Brisbane, Queensland.
1895 Robert Etheridge, Junr., Government Palæontologist, Curator of the Australian Museum, Sydney.
1896 *Hon. Augustus Charles Gregory, C.M.G., M.L.C., F.R.G.S.
1900 Sir John Murray, Challenger Lodge, Wardie, Edinburgh.
1901 *Edward John Eyre.
1902 F. Manson Bailey, F.L.S., Colonial Botanist of Queensland, Brisbane.
1903 *Alfred William Howitt, D. Sc. *Cantab.*, F.G.S., Hon. Fellow Anthropol. Inst. of Gt. Brit. and Irel.
1907 Walter Howchin, F.G.S., University of Adelaide.
1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

Money Prize of £25.

1882 John Fraser, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney for paper on 'The Tin deposits of New South Wales.

1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper on 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper on 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper on the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper on 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, B.Sc., M.B. *Lond.*, Sydney, for paper on 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper on 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By W. MOGFORD HAMLET, F.I.C., F.C.S., Government Analyst for the State of New South Wales.

[*Delivered to the Royal Society of N. S. Wales, May 5, 1909.*]

"The whole of modern thought is steeped in science; it has made its way into the works of our best poets, and even the mere man of letters, who affects to ignore and despise science, is unconsciously impregnated with her spirit, and indebted for his best products to her methods. I believe that the greatest intellectual revolution mankind has yet seen is now slowly taking place by her agency."—Huxley, "Collected Essays," Vol. VIII, p. 226.

Continuity of thought and speech are preserved to us in our common language, which it has been well said is a veritable museum of antiquities, for we possess among the most ordinary words in common use, words more ancient than the pyramids of Egypt. Emerson says that "as we go back in history language becomes more picturesque, until its infancy, when it is all poetry; or all spiritual facts are represented by natural symbols." And thus it is with the simple word 'chair,' which comes down to us with a long pedigree from the Sanscrit, through Norman channels, and in early times meant a shelf, or bench; both[1] 'bench' and 'chair' being still used for the dignified position of a judge or a University professor when speaking *ex cathedra*, as well as for the speaking pedestal of the President of a learned Society. With the old Norsemen, their highest and holiest god, Woden, (Wotan) whose name is given to this (Woden's day) our meeting-day of the Royal Society, had his throne or chair the highest seat in Asgard, and was then known by the name of Hlidskialf, which is still

[1] Max Muller, "Fors Fortuna," p. 2.

in every day use as our word 'shelf,' and for some of the most necessary parts the shelves of all our laboratories physical or chemical, and this is just an instance of the continuity of speech from the old-time Norsemen away back in the twilight of the gods, down to the present day. But let it also be noted that the throne of Woden was not merely a chair-shelf, but a mighty watch tower, from whence he could overlook the whole world and see at a glance all that was happening among gods and men. Matthew Arnold finely expresses the legend when he says:—

> " From the hall of Heaven he rode away
> To Lidskialf, and sate upon his throne,
> The mount, from whence his eye surveys the world.
> And far from Heaven he turned his shining orbs
> To look on Midgard, and the earth, and men."

From this ancient conception of so exalted a position our thoughts turn to the responsibilities of the presidential chair of our Society, whose occupant is a passing temporary phenomenon, here to-night and gone to-morrow. But not so the chair whose existence carries us back to the historic Sir Thomas Brisbane who occupied it in the year 1821, and whose name will for ever be cherished in Australia. Thus we note the continuity of occupation, and if the post be charged with the cares and responsibilities of office, the burden is happily counterbalanced with advantages and privileges peculiarly its own, not the least of which is the opportunity for a calm and dispassionate survey of the fields of scientific research, as well as the state of knowledge, aye, and the lack of knowledge in our midst.

Carlyle, who was saturated with the myths and legends of the Northern heroes, had his own clear conception of the Scandinavian god Woden surnamed the Allfather, occupying the highest seat or Lidskialf in Asgard, and you will no doubt remember his graphic picture or character-sketch of Professor Teufelsdröckh sitting in *his* chair or

shelf, high up in the watch tower and pinnacle of Weissnichtwo, from which vantage height, sitting at ease, he could see the life circulation of that considerable city. Carlyle thus proceeds with his story:—"I look down into all that wasp-nest or beehive," we have heard him say, "and witness their wax-laying and honey-making, and poison-brewing and choking by sulphur . . . that living flood, pouring through these streets, of all qualities and ages, knowest thou whence it is coming, whither it is going? *Aus der Ewigkeit zu der Ewigkeit hin*:—'From Eternity onwards to Eternity.'" But Teufelsdröckh perched up in his high Wahngasse watch tower, fighting his battle with Dullness and Darkness, looking down into the wasp's nest of Vice and Misery is no far-fetched impossible picture, for I see from my chair not only the stinging wasps but the Drones of Society, Traders of the Turf, the Parasites of the People yawning with ennui and reeking with whisky, and the easily deluded simple ones beguiled by the crafty and cunningly worded advertisement that conceals the baneful poison in the gilded pill. I look down upon our social environment and I behold the happy hunting ground of advertising knavery with all their uric acid, backache and tubercular cures, assorted liniments, "new discoveries" and what not, all trading upon the disordered digestion and imaginary maladies of the poor hypochondriac. What shall we say of this Augean stable? What shall we say, for instance, of the robber who puts up powdered sugar into artful medicine-like powders and demands a golden guinea for what he says will cure paralysis? or, of another who sells distilled water as a remedy for consumption? or, of the poor workman who is assured by his blood-sucker, that his chances of being cured depend on the proffered electric belt for which he must pay forty pounds sterling of the current coin of the realm. From all such noisome nonsense may our world be soon delivered! From the giddy

vortex of credulity and the whirlpool of falsehood, from that whirling Eddy that deludes itself under the pretence of Science and forsooth calls itself Christian, may the world be soon delivered! Verily is credulity a sloughing sore that demands the powerful cautery of satire and exposure!

But it is not necessary to dilate further on superstition and fraud: let us turn to brighter things, for there is happily a nobler subject before us to night, namely the presentment of the progress of science during the past year; for superstition based on constructive credulity has grown to be incongruous with intelligence, and Teufelsdröckh may now look down into the nebulous haze, and see the shining shafts of light, for lo! the search-light of science sweeps round upon the wasp's nest, and the people walking in darkness shall behold at last the light. We rejoice to report that science is slowly but surely overcoming the inertia of ignorance, and the yearly progress of scientific work shows that great advances have been made. The work of the Royal Society is sharply divided into two divisions:—First, contributions to original research, and secondly, the delivery of popular science lectures, whereby the net results of scientific activity are put into commendably plain speech within the comprehension and understanding of ordinary people. May I put before you some of the work now engaging the study and attention of some of our workers in New South Wales?

It is the work of men in the very forefront of the battle, valiantly fighting on the frontier of the limitless country of the unknown; and the victories gained are chiefly due to the advance made in physics and physical methods; we find this permeating all branches of scientific work. Even in the most superficial survey of say, modern physiological literature, it is at once apparent that physics and chemistry underlie the whole of the work. It has now become the

practice to speak of the fusion of chemistry with physiology by the simple term Bio-chemistry, and the Physiological Laboratory of the University of Sydney reports good work done in this subject. Dr. Chapman has continued investigations on the gravimetric relations of the antiserum and homologous proteins interacting in precipitin reactions. It has been shewn that the weights of precipitum are directly proportional to the quantities of antiserum employed, that a certain weight of protein gives a maximal weight of precipitum from a definite quantity of antiserum, and that further increase in the weight of protein fails to increase the weight of precipitum from the same quantity of antiserum. Further experiments on the action of brucine and strychnine on *Hyla aurea* have shewn that while *Hyla* is strongly resistant to poisoning by strychnine it is equally susceptible to poisoning by brucine.

Mr. E. C. Grey is at present engaged in the study of the lipoid bodies and their relationship to the fats. It is hoped incidentally to improve the methods for estimation and separation of these phosphatides, which at present are merely qualitative, inasmuch as Bang has shewn that the methods of Bergell, Diakonow and others are quite inadequate, moreover although Erlandsen has pointed out the best way to obtain the greatest yield of phosphatides, he cannot be said to have settled the question of the purification of even the simplest, namely lecithin. At this moment examination is being made of the fatty radicle of brain lecithin, and the same method will be applied to phosphatides of other sources. With Dr. Petrie, Dr. Chapman has also isolated and estimated the hexone bases arginin, histidin, and lysin present in the protein of egg-white. This is probably the first occasion that the hexone bases of a protein have been estimated in a British or colonial laboratory. Dr. Petrie, the Linnean Macleay Fellow in

Bio-chemistry, working in the physiological laboratory of the University of Sydney, published last year the discovery of a new Solanaceous alkaloid, obtained from *Solandra laevis* growing as an evergreen shrub in the Botanic Gardens. The new alkaloid belongs to the atropine group and resembles hyoscine. It produces strong dilatation of the pupil, and is a powerful nerve and muscle poison. The name 'Solandrine' is proposed for this new substance.

Dr. Petrie has also published in the Journal of the Linnean Society of N. S. Wales an historical summary of the literature on plant nitrogen, in which he traces the life-cycle of the compounds of nitrogen and the part played by these in the metabolism of plants. In the same Journal is published the results of a number of experiments on seeds, showing the proportion of the total nitrogen which actually exists as protein. It has been the custom to regard the nitrogen of ripe seeds as existing almost entirely in protein, whereas his experiments shew that as much as half the nitrogen may be present in non-protein compounds.

During the year an important change has been made in the performance of microbiological work by the Government. Formerly there existed one well equipped bacteriological laboratory associated with the Department of Public Health, and two or three other small imperfect ones in the Department of Agriculture. The reconstruction of the latter department involved proper provision for the performance of the microbiological and biochemical observations which have now become an integral part of scientific agriculture. It was at first proposed to create a separate institution for this purpose, but having regard to the essential unity of the operations even though designed to effect different ends, the Cabinet decided to make use of the plant and equipment already available in the microbiological laboratory of the Board of Health, and, by enlarging

the space and staff, have converted it into a separate sub-department, under the designation of the Bureau of Microbiology, and charged it generally with the performance of the microbiological work of the Government. Its functions may be divided into ordinary business and research. In the former capacity, the Bureau is called upon to advise concerning microbiological specimens of all kinds submitted to or acquired by Government Departments in the course of their ordinary work. The daily routine in this respect comprises, on the pathological side, the examination of specimens for evidence of such infectious diseases as diphtheria, typhoid, tuberculosis, and plague in human beings; swine fever, anthrax, blackleg, and actinomycosis in the lower animals; of parasites, of tumours, and of diseased tissues generally; on the agricultural side the examination of samples of milk, cream, butter and cheese; of water and soils, of fruits, and plants affected with mildews, spots, smuts, rusts, rots, or blights for which various fungi are responsible. The research work covers the fields of human, animal, and plant pathology, the microbiology of soils, crops, and farm products; of the dairy, butter and cheese factory, and generally of the production and distribution of foods, of the fermentation industries and of the putrefactive wastes. The exploration of the parasitic fauna and flora of domestic animals and of plants, the distribution of cultures of lactic acid bacteria for dietetic and dairy purposes; the investigation of nitrifying bacteria and those of the root-nodules of leguminosæ in their relationship to agriculture, and the preparation of therapeutic vaccines, may be mentioned as indicative of the lines of research now receiving attention. I think you will agree that its scope suffices to show that the newly created Bureau is designed to perform services from which not only the State, but the scientific world at large may prospectively benefit. The staff includes the director, Dr. Frank

Tidswell, M.B., Ch.M., D.P.H., and Dr. J. B. Cleland, M.D., Ch. M., Dr. A. E. Finckh, M.B., Mr. G. P. Darnell Smith, B. Sc., F.I.C., F.C.S., and Mr. J. Harvey Johnston, M.A., B. Sc.

Publications in biochemistry are pouring forth from workers in all parts of the world in a constant steady stream, and form a wealth of materials from which it is difficult to make any selection without overloading my discourse, but I must mention the discovery of a group of bodies termed by Overton the lipoids. These lipoids are contained in the outer layers or cell-membranes, and become the means by which narcotics, anæsthetics, and poisons obtain an entry into the cell and set up their specific action. It would appear that common intoxication is the result of the injury by alcohol to these lipoids, since ethylic alcohol is soluble in fats and thus displaces the lipoidal and non-lipoidal protoplasmic constituents from their normal and active conditions.

In recent work in bacteriological investigations perhaps the most startling discovery of the last few months has been that of the presence of the *Bacillus typhosus* in the urine of persons who have once suffered from typhoid fever. The patients may be convalescent or may have apparently completely recovered, but they still go on spreading enteric fever in the most mysterious manner through their excreta. They therefore become dangerous agents in the propagation of this malady and are now regarded as "typhoid carriers" unsuspectingly spreading the disease, and probably becoming the primary cause of many new epidemic and endemic outbreaks of typhoid. Recent investigations shew that about four per cent. of convalescent cases become chronic carriers; up to the present a practical method of treating these chronic carriers has not been devised, and some bacteriologists believe that "once a carrier, always a carrier." It is now recognised that patients, who have

suffered from typhoid fever, may have the germs of the disease left in their bodies, *e.g.*, in the intestines, the gall-bladder, and the urine, for long periods after they are pronounced convalescent, and, presumably, free from infection. The gall-bladder theory is the explanation offered officially in connection with a localized outbreak of typhoid fever, consisting of 126 cases (8 deaths) in Glasgow and the neighbourhood. Milk became infected, with the result that the epidemic or outbreak occurred. Enquiries show that 500 households were affected in that they consumed the infected milk, that the 500 households consisted of 2,500 persons, that the attack rate was from 4 to 5%, whilst the case fatality was 5·5%. Bacteriologically, the source of the disease was traced to a woman milker, who had had an attack of enteric fever sixteen years previously, and had since been, on several occasions, associated more or less clearly with outbreaks of illness which proved to be enteric. The typhoid bacilli were found in her dejecta (5,000 per cubic centimetre), and her blood gave a positive Widal reaction. The chain of evidence was complete, showing the outbreak of typhoid as caused in the first place directly from the milker, and afterwards indirectly. Chronic typhoid carriers have been found at periods varying from a few weeks to as much as forty years after the attack of the fever. In some cases there were no clinical symptoms of typhoid fever, but, in this connection the typhoid was simply regarded as influenza, pneumonia, meningitis, etc. Of the chronic typhoid carriers, women form by far the larger proportion (about 75%), the bacilli finding a habitat in the gall-bladder, passing down at intervals into the intestines, to be voided with the stools. Another important discovery, that I hope will be grasped by every civic authority, shire council, and municipality throughout Australia is that of Dr. Andrews of the Local Government Board of England, and that is, the fact that pathogenic

organisms may be borne, carried about, and transmitted by sewer gas; this of course offers a ready explanation of the propagation of many infectious diseases.

Turning to contemporary work in natural history, I note that the new wing of the Australian Museum is on the point of completion, this will provide two magnificent galleries, a lecture theatre and additional work rooms. The Linnean Society of New South Wales continues its successful career. The magnificent bequests of Sir William Macleay enabled it to appoint another research fellow in the person of Mr. Leo Cotton, late of the Antarctic Expedition. Three fellows and a bacteriologist are now maintained in constant and continuous research. In zoology our member Mr. Chas. Hedley, has completed and published a memoir on the deep sea mollusca of Tasmania, in conjunction with the local naturalist Mr. W. L. May. No deep dredging had previously been attempted in these waters, and the work of these gentlemen has considerably enlarged the known fauna. The mollusca of the Great Barrier Reef have been the subject of Mr. Hedley's continued study and another memoir on these tropical shells approaches completion.

During the year several important papers on certain archaic forms of freshwater crustacea from Tasmania have appeared from the pen of Mr. Geoffrey Smith, an Oxford biologist, who visited Tasmania to procure his material. At the present time when public attention is concentrated on Antarctic problems, it is interesting to remark that Mr. Smith finds in these ancient shrimps new and convincing arguments for a former extension of Antarctica to Tasmania. In this he is supported by Mr. E. J. Goddard, a brilliant pupil of Professor Haswell, who during the past year has published a series of articles on freshwater worms discovered by him on the mountains of Tasmania. An

important monograph of the Archaeocyathinæ has been completed by Mr. J. Griffith Taylor of Sydney, but now in residence at Cambridge, England. These ancient fossils of obscure affinities form extensive "coral reefs" in the Cambrian deposits of South Central Australia. In the heart of Australia occurs the greatest palæozoic reef in the world, while the greatest of modern reefs extend along the shore.

Dr. Johnstone Stoney aptly tells us that "a theory means a supposition that we hope to be true." Such a theory is that advanced by Mr. Hedley regarding the marsupial fauna of Australia having travelled from its place of origin in the northern hemisphere through South America and the radial prolongations of a lost Antarctic Continent into Tasmania and Australia, Tasmania being regarded as structurally and historically a part of the great Australian Continent. The writer of a charming book on Natural History[1] thus speaks of Mr. Hedley's work:—"A great deal of evidence bearing on the existence of Antarctica could be drawn from the study of other groups, *e.g.*, the Mollusca, which have formed the special study of Mr. Chas. Hedley, of Sydney, himself a convinced believer and advocate of the theory. I have chiefly wished to emphasize certain typically temperate and alpine groups of the southern hemispheres, because from them it seems to me, that the strongest evidence is to be obtained, and perhaps the most interesting development of the future will be the working out of the invertebrate animals of the Andes from this point of view." And this brings me by easy and natural transition to the splendid work accomplished by the British Antarctic Expedition of 1907–1909 under the renowned leadership of Shackleton, in which our honoured past

[1] A Naturalist in Tasmania, by Geoffrey Smith, Oxford, Clarendon Press, 1909, p. 142.

president, Professor David, took so important and interesting a part, fearlesssly penetrating the regions of eternal ice and snow, like the Vikings of the land of Olaf and Odin, but with a modern spirit of research and discovery striving to win the secrets of the earth that lie hidden under the Southern Polar Ice cap, and to stand on that point of the earth where the force of terrestrial magnetism is concentrated—the exact *locus in quo* of the southern magnetic pole. The keen local interest in this expedition was intensified in no small degree, owing to our geographical proximity and to the personnel of the brave explorers themselves.

The scientific world at large is keenly looking forward to the publication of the series of volumes of valuable results which will enlarge our conceptions of the great Antarctic Continent, and yield a harvest of geological, biological, magnetic and bathymetric knowledge that will be unique of its kind. What the value of such expeditions will be may be best appreciated by generations yet to come who in watching the gradual cooling process of our planet will gauge the increasing growth of the mighty fissured glaciers and mark the climatic changes that await posterity in Australia and New Zealand. Citizens of Sydney have already given their hearty congratulations, but once again the Royal Society of New South Wales welcomes back these modern Vikings from

"Those wastes of frozen billows that were hurled,
By everlasting snow-storms round the poles,
Where matter dared not vegetate or live,
But ceaseless frost round the vast solitude
Bound its broad zone of stillness."

The home-coming of Prof. David from the blizzard-swept and ice-bound regions of Antarctica has been a subject of universal congratulation, and we are glad to have him back unscathed from the perils encountered in his journey to the South magnetic Pole.

And what shall we say of that royal kingdom of science we call physics, that is now slowly but surely penetrating, if not capturing all other divisions in the realm of nature, and whose extraordinary discoveries surpass everything known in the past, fusing itself with chemistry into so intimate a relationship that one can hardly say whether physical chemistry shall henceforth stand as a separate science or be relegated as a mere continuation or refined sublimate of physics. Indeed the ideas of last year prepare us for the discoveries of this year, for the germ found a few months ago multiplies with such vigour and fecundity that it is *in potentia* the actuality of to-day. The omnipresent bacillus is even surpassed by the mobile and ubiquitous ion—an entity in itself—that engrosses so much attention as to command a journal published for its sole discussion. The ion enters into commerce and is harnessed up already in many industries, for I hear of the use of the silver ion as a means of sterilising doubtful drinking water. New systems of thought and procedure are evolving fresh ideas that revolutionise our conceptions of matter for present day research goes to the very foundation of things and profoundly modifies our notions of matter.

The Zeeman effect provides us with the means of detecting electro-magnetic disturbances on a large scale by means of a luminous vapour drawn across the poles of a powerful magnet, and when viewed through the spectroscope the lines of force appear as doublets. Prof. Hale of the Mount Wilson observatory in making use of the Zeeman effect made a very striking discovery in the spectra of sun spots. The observation indicates the association of strong magnetic fields with the spots due probably to vortices of charged particles, and the discovery may lead to important developments in our knowledge of the connection between solar and terrestial phenomena.

Perhaps the most remarkable discovery in physics during the year is the accumulated and convincing evidence that the particle of radio-active change is an atom of helium, and this point is of fundamental importance in the theory of atomic disintegration and may be considered as now finally settled. At our Sydney University, Prof. Pollock is engaged in the interesting work of the ionisation of the air, and has with his collaborators contributed several papers to the Society on this subject during the year, as well as contributing some interesting exhibits of experiments in radioactivity at the Royal Society's conversazione. In the progress of science new methods and ideas are continually appearing, perhaps the most marvellous of late years being the phenomenon of matter spontaneously radiating energy into space, and even penetrating other forms of matter, giving rise to changes in atomic constitution; as already mentioned, the α-particle being ejected into space as the element helium; thus reviving the prophetic theories of Sir Isaac Newton, and later of Sir William Crookes. In order to prove that an α-particle consists of an atom of helium plus a positive charge, the purified emanation from 0·12 gram of radium was compressed into a capillary tube with walls 0·01 mm. thick. This capillary tube was known to be impermeable to helium, but the particle and also radium-A and radium-C could pass through it into a stout outer tube, where the spectrum could be examined. Although after twenty-four hours no trace of helium was detected, the spectrum gradually developed until, after six days, all the lines of helium could be seen. This helium must have been produced from α-particles which, after traversing the glass, had slowly lost their charge.[1]

In chemistry, Sir William Ramsay has given us a much clearer view of the functions and properties of the electron.

[1] Ernest Rutherford and T. Royds, Phil. Mag., 1909, vi, 17, 281 – 286.

He propounds the idea that non-metals are bodies which have a strong affinity for electrons, while metals are bodies with but slight affinity, and thus indicates the phenomenon of predisposing affinity. To the electron he assigns the symbol "E" and the hypothesis is thus summed up:—"Electrons are atoms of the chemical element, electricity; they possess mass; they form compounds with other elements; they are known in the free state, that is, as molecules; they serve as "bonds of union" between atom and atom, and the simple equation that symbolises the union of sodium and chlorine should henceforth be written as E Na + Cl = Na E Cl. Sir William Ramsay thus summarises his arguments for the disintegration or breaking down of the elements:—

"The conversion of an atom into an ion by gain or loss of an electron completely changes the property of the element. Certain elements, termed radio-active, are losing electrons and changing into other forms of matter which have equal claims to be considered elementary. Under the influence of ultra-violet light many metals (tin, etc.) lose electrons, but no proof exists that they yield other elemental forms. Loss of electrons is coincident with an enormous evolution of energy in a concentrated form, so that probably change from one elemental form to another will be manifested, like chemical change, by gain or loss of energy. The irregularity of the numbers representing the atomic weights can be represented on the hypothesis that the addition or subtraction of definite groups of electrons is the cause of their divergence from a perfectly regular series."

Prout in 1815 advanced the theory of a fundamental basis of matter called 'protyl,' of which all the elements are but modifications, and that the numbers we call atomic weights are multiples of hydrogen, and should therefore be expressible by whole numbers. Egerton in February last published a research which Sir William Ramsay describes as an epoch making paper, which briefly put is as follows:—The atomic

weights of the first fifteen elements have been calculated according to a simple formula, in which a constant (·0078) is multiplied by a constantly increasing whole number in order to obtain the divergence from whole numbers of the atomic weights. The atomic weights of the next thirteen elements have been calculated according to a slightly modified formula. The agreement is, in nearly all cases, to the second place of decimals, therefore the relation suggests a modification of Prout's hypothesis. The suggestion is made that the numerical constant is a fundamental atomic weight or the mass or mass-function of an electron, and therefore the elements are electron complexes increasing in complexity directly as the atomic weight increases. During the year the liquefaction of helium has been accomplished.

The Challis Professor of Engineering--Professor Warren—has been doing valuable work amid the inconvenience and difficulties of rebuilding and remodelling his laboratories and testing rooms. His work on timber testing is especially interesting, including as it does the relation of strength to percentages of moisture, tensile, shearing strength and elasticity, resistance to suddenly applied loads, resistancy to splitting and hardness. The great importance of our timber supplies is evident when it is computed that the value of timber in America exceeds the combined value of their output of both iron and steel. Timber, he says, represents great sums of money, and it is clearly the duty of our State to conserve our forests for our own use and for our descendants, more especially as timber, compared with structural steel as a building material, has greatly increased in importance.

With timber and forestry is closely associated that ancient industry agriculture with which chemistry is more than ever identified. So pronounced is this fact that our Department

of Agriculture cannot now dispense with its aid, and a well equipped laboratory and scientific staff is presided over by our agricultural chemist, Mr. F. B. Guthrie, F.I.C., F.C.S., who in addition to the ordinary routine work of analysing soils, fertilisers, and agricultural products, reports the following special investigations: the chemical examination of different grasses cultivated with the special object of determining any alteration of composition due to differences in soil and climate; the study of the effect upon the retention of water in the soil at varying depths and methods of soil treatment; the effect of alkaline bore water on the land; investigations on the nature of different varieties of grain, particularly in respect to their milling qualities and the nature of the flour produced.

In Eucalyptology, Mr. Henry G. Smith, F.C.S., of the Technological Museum in a paper before this Society showed that the elastic substance of the young shoots of certain species of Eucalyptus and Angophora was caoutchouc. By the action of light and air this rapidly changes into a white powdery substance, the nature of which is at present undetermined. The white glaucous appearance of the young shoots of certain eucalypts was, at the same time, shown to be due to the presence of a vegetable wax. The phytochemical investigations of the pines of Australia, carried out in conjunction with Mr. R. T. Baker, the Curator, is now practically completed and will be published during the present year. This work has now extended over a period of ten years, and embraces practically the whole of the pines of the continent, including those of Tasmania. Several new facts in connection with the Coniferæ have been brought to light. The sesquiterpene alcohol, guaiol, has been isolated from the timber of the *Callitris*, where it occurs together with a new phenol (Callitrol). It is probable that this latter substance is the

one which is objectionable to white ants. It is hoped that eventually the structure of the molecule of this substance will be determined so that its synthesis may be established. It might be expected to act as a protection to other timbers against these pests. Other chemical substances, new to science, were also found occurring naturally in the Australian pines; these are to be described in forthcoming publications on these trees. The phytochemical work in connection with the Eucalypts and the Melaleucas has been continued during the year, the results of which will eventually be submitted to the Society.

Dr. Walter Spencer is doing yeoman's work in bringing science into the body politic by establishing a New South Wales branch of the British Science Guild—a truly missionary effort, whereby the nation is awaking and beginning to realise the importance of the scientific spirit. I earnestly commend the subject to your favourable notice and to the attention of politicians, for no less an authority than Mr. Haldane solemnly averred that "All the controversies that now agitate the minds of politicians were of less importance than the big question of how to make the permanent element in politics more powerful and better." There was too little science in it at the present time, and there was hardly a department in the public service which did not require the aid of science if it was to be effective; was it impossible to hope for the birth of an era when the head of the Government should have at his disposal a corps of the finest brains which the nation could produce? It is the unanimous desire of all the learned Societies in Great Britain and her oversea dominions and commonwealth to see that heads of Government will see their own way to recognise the great work of the British Science Guild. The work of our Royal and Linnean Societies not only fosters the advance of science but is largely educational, and this

educational work is of the highest type, as it follows on after the ordinary general education is finished. We in Australia hear the echoes of unrest throbbing along the insulated cable that stretches like a bundle of nerves from the mother country, and the messages really mean that there is work for the British Science Guild multiplied a hundred times over to be done, in wakening people out of the delusion that you can improvise when the time of stress and danger comes upon us and that there is no need to take thought beforehand.

In that singularly charming and beautiful branch of science, botany, I am glad to say Mr. J. H. Maiden, the Government Botanist, has completed a work of vast magnitude, namely the permanent establishment of a National Herbarium, housed, classified and protected from ravaging insects in the same building as the somewhat small and little known botanical museum. Mr. Maiden is engaged on the great work of his life, the critical revision of the genus Eucalyptus; he has completed his Life of the Father of Australia, Sir Joseph Banks; and amid his many duties is ever doing the good work of beautifying the City of Sydney, and maintaining and jealously guarding our open spaces, so that generations to come shall not be deprived of their full percentage of oxygen, and still more nobly contending for what—unless cared for in time, will soon become a lost heritage—our forests and our economic timber supply, a responsibility that rests very lightly on the consciences of those immediately concerned in their preservation. Mr. Maiden tells me that there have been added to the National Herbarium during the past year, large numbers of plants in all the sections to which it is divided. Details are given in the Annual Report of the Botanic Gardens. His *magnum opus*, the "Critical Revision of the genus Eucalyptus," has now reached the tenth part, with 48 plates, completing the

first volume. His "Forest Flora of New South Wales" has now reached the thirty-fourth part, with 130 original lithographic plates and a very large number of photographic illustrations, while a second part of "Illustrations of New South Wales Plants not previously depicted" has also appeared.

In regard to oxygen, the advantage of an unlimited supply of fresh air with its full complement of oxgen, is more than ever emphasised by the discovery of the use of oxygen as the most powerful lung purifier we know. Dr. Leonard Hill speaks of it as a new factor in physical efficiency, and in a number of experiments on athletes at the 'Varsity and Olympic games, cricketers, footballers, and on racehorses, he finds that the waste products from muscular exertion are so rapidly oxidised that the sensation of fatigue is abolished, and the body is capable of a far greater output of energy, and this without any detriment to the body. The fact that breathing oxygen does no harm is shown by the condition of the men who wear the Fleuss-Siebe-Gorman rescue apparatus for use in poisonous atmospheres, as in mines after explosions. The men breathe oxygen for two hours at a time, and do the hardest work when being trained in the use of this apparatus. Some of these men have worn the apparatus frequently for the last two or three years, and are in perfect health. He says, I have for the last six months taken oxygen frequently before and after running and bicycling, and am now much fitter than I was before these tests, and all this simply explains why the sedentary resident in towns, longs for the mountains, the country or the seaside, and goes to places where not only the full quantity of oxygen is to be obtained, but where it is fresh and not devitalised.[1]

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[1] Influence of Oxygen on Athletes, Leonard E. Hill and Martin Flack, Journal of Physiology, 38.

One of our past presidents, Professor Threlfall, F.R.S., on March the 10th, lectured at the Royal Institution in London on experiments at high temperatures and pressures, when he exhibited apparatus capable of producing a pressure of 100 tons on the square inch and the temperature of 2,000° Centigrade. Referring to the earth's heat, he proposed to tap the earth's heat energy by driving a shaft twelve miles deep into the crust of the earth. He suggests that it would be a good thing on the part of some millionaire to spend five millions of money in its achievement, the work requiring eighty-five years to accomplish.

One event of the year of no mean magnitude has been the coming of age of the Australasian Association for the Advancement of Science, which twenty-one years ago was founded in this city in these very rooms by Professor Liversidge, who was its first general secretary, and whose mantle has fittingly fallen on Mr. J. H. Maiden. Our memories go back to the preliminary meetings twenty-one years ago, when a band of earnest science workers including Dr. George Bennett, Sir Alfred Roberts, Sir Edward Strickland, Dr. Howitt, Mr. Mann, Mr. Russell, Professor Stephens, Captain Brett, C. S. Wilkinson, Gilbert Parker, Mr. Montefiore, the Baron von Mueller and a number of those still living were instrumental in its foundation. At the meeting of the Association in Brisbane last January, some illuminating and suggestive addresses were given on the electronic theory of matter which now pervades the domains of chemistry and physics, to the greater elucidation of those foundational principles of affinity and chemical actions.

Another event of the year is the occurrence of the Darwin centenary, to be celebrated in Oxford in August next, by delegates and representatives from all parts of the world. Our own Society will be ably represented by Professor Liversidge, who will present an address on behalf of our

members to do homage to one who has been aptly termed 'the Abraham of Science, and a searcher as obedient to the command of truth as was the patriarch to the command of God.' His brilliant and far reaching work we claim as a priceless heritage, and as the master-key used in unlocking the secrets in all branches of knowledge. We apply the principle of evolution alike to the development of the minutest bacillus seen on the stage of our microscopes or the highest mammal as well as the nebulous assemblage of star dust to the remoulding of the social status of man himself, in a word it is evolution that becomes our guiding principle in science.

The analytical and synthetical processes in pure chemistry are still flowing onwards like the mighty volume of a river, through new and unknown country, yielding a continuous series of revelations in myriads of transformations and permutations that at once defies and bewilders the imagination of the best of us. In pure chemistry it is the despair of the present day chemist to follow the carbon atom in the long and complex chains of new bodies revealed by the synthetic method. Chemistry is the most prolific branch of knowledge now known to man, and last year's output of new facts requires four big volumes of an aggregate of 3,800 pages to contain them. I shrink aghast at the impossible task of presenting this mass of new discoveries in chemistry. Each man must perforce till his own little plot and dig his own insignificant furrow; for myself I can only casually point out a department in chemistry, namely the autonomous science of State Chemistry which widens its borders every day and is of growing importance in all parts of the British Empire. It is of special importance and interest to us in New South Wales, since our Premier the Hon. C. G. Wade has recently introduced, and Parliament has now passed the Pure Foods Act of 1908, which comes

into active operation on the 1st July next. An advisory committee has been appointed under the act to frame regulations and establish definitions and standards of purity for all articles of food and drink, drugs, disinfectants, medicines, colouring materials, food preservatives, and even food colouring materials. A leading principle adopted deals with the correct labelling of food stuffs sold in packages, cartons and hermetically sealed tins. That principle is, that the public have a right to know, by a printed declaration on the outside what is inside the package both as to quantity and quality. So that it shall be no longer possible for a manufacturer to palm off a food adulterated with eighty per cent. of foreign inert matter that the consumer is helplessly and unsuspectingly compelled to take and pay for in lieu of the pure article. Whenever it is deemed permissible for a harmless addition of foreign substance to be added to enable the seller to offer a food at a lower price, a clear printed statement to that effect must be recorded on the label in type, sufficiently large as not to require a magnifying glass to see it. Obviously, fraudulent mixtures have been, and are, the direct result of unprincipled competition in trade. The trade demands a cheap article, and the manufacturer of course is always ready to meet the demand. It is just here that the Pure Food Act will be welcome to the honest manufacturer, inasmuch as a definite rule will be laid down as to the standard of quality to which the whole trade must comply, and which must therefore tend to equalise the conditions of sale all round and prevent any undue advantage on the part of the unscrupulous adulterator.

The progress of original research in science quiet, and unobtrusive like the rising tide, bears with it facts that may await years and years for explanation and co-relation: no one can foresee their application and far reaching application. Thus, the Geissler tube led to the high vacua tubes

of Crookes, which in turn led the way for Rontgen and Lenard, preparing the way for Becquerel and Madame Curie with all the brilliant discoveries in radiant matter. Radio-activity and the upheaval of our notions of the atomic theory has been fruitful in a big harvest of results, but one of the most prominent workers and discoverers has been laid to rest during the year, I mean M. Henri Becquerel, whose researches have had no small share in this essentially modern work, since it was he who in 1896 first found the radiations from uranium. New ideas of matter in solution on the one hand and the radio-activity of solids on the other throw a flood of light on the very fundamental principles of the constitution of matter. In the light of the ionic theory the extremely simple act of dropping a few grains of common sugar into a teacupful of water is pregnant with deep philosophy, for the process of solution takes place and affords an insight into molecular action: the molecules endowed with movement exert a pressure, the magnitude of which depending on the degree of concentration, the pressure, volume, velocity of the molecules; the conductivity and the molecular weight all being deducible from the simple act of solution, while the work performed is the work of the ions in rhythmic order and precision. It is the parallel of the

"Flower in the crannied wall,"

or the primrose of Peter Bell which to the unthinking is but a primrose still. Thus the simplest phenomenon provides us with matter for deep reflection, and is it not Goëthe who tells us that the commonest natural object is a window through which we may look out into the infinite? Whatever view we have from this window, however dim or imperfect when seen "through the glass darkly," let it be our firm determination to see as clearly as we may, and act accordingly. Not in cultured idleness, nor in vain reflection, but with faculties strung up to worthy toil and enterprise,

recognising our mission, our object and condition of existence; nay our best enjôyment is to do that work which brings its own reward of happiness to the human mind when Nature reveals to us her wondrous secrets.

Civilisation and the advancement of science march together in unison: precise and exact reasons of the why and wherefore of the phenomena of the universe, is the direct outcome of modern research, so that if this century or even this year be compared with its predecessor, we shall find that the sublime commanding aspiration of the poet,

"Let knowledge grow from more to more,"

is now more than ever realised. And it is to labourers in science I address myself, who taken collectively may be recognised as the highest and most distinguished labour party in existence, an estimate modest enough when one considers that it is the dynamic potentiality of the science worker, who has been true to his vocation, that has helped to make the world what it is to-day, and it is a glory to be enrolled in a labour party of the immortals that include the names of Newton, Harvey, Dalton, Jenner, Banks, Faraday, Clerk-Maxwell, Joule, Tyndall, Stokes, Hertz, Huxley, and Kelvin.

But above all the most brilliant aspect of science is its perfect continuity, whereby each new fact dovetails with all that has gone before, for the newly discovered fact apparently isolated, naked and implacable, is by and by found to fill a niche in the edifice of science, and indeed drops like a jewel with marvellous fitness and measure into its own indispensable and appropriate setting. With continuity in progress comes the idea of continuity in space from our own bodies right away through the ether to the outposts of the universe, a thought we owe to the inspiration of Lord Kelvin, and now practically realised every

time we send an electric wave rippling through space in our modern etherial telegraphy to be intercepted by a receiver placed at a given distance, yet even this is eclipsed by our everyday system of recording wave-messages now on their way from the furthest so-called fixed star, to be recognised by their spectra. Thus winged thought brings us to that fundamental idea of continuity of existence without break or interruption that Sir Oliver Lodge[1] insists upon as needing "inculcation more generally among people of the present day."

And here I tender my friendly farewell, believing that the Time-Spirit demands now and then some general presentation of the many and diverse groups of facts systematically classified and generally labelled as science. This I have endeavoured to do, all too conscious that my efforts are but desultory, and perhaps wide of the mark after all, yet one feels that it would have been both inadequate and unsatisfactory to have limited our attention to a single specialised branch of knowledge that only appeals to the few. Here in Australia, we live at the nerve-exciting terminals of our electric news-distributors, and something may be said for the heterogeneous array of new facts in science thrust upon our attention by means of the cablegram, often in the form of an astonishingly bald statement, to be afterwards confirmed, modified, or discounted by the fuller accounts published in the scientific journals. These facts, when collated and placed in their relative niches in the temple of science, all point to the one consentaneous generalisation, that there is no solution of continuity in our polyphased aspect of this great and beautiful universe. It is moreover in the contemplation of this grandeur of unity that we sometimes feel like one who having at last found his way through the maze of labyrinthine passages

[1] Substance of Faith, p. 105.

of scholastic dogma, escaping many a disappointing *cul de sac* of fruitless research, finally emerges into fine open country, into the refreshing green pastures and beside the clear waters of truth, where blossom the fruitful trees of science, affording light, wealth and substance for the whole world, Eastern, Western, European and Australian alike.

I now come down from my imaginary watch tower: I vacate the chair for my worthy successor with the full conviction that the scientific spirit in Australia throbs in unison with the life and aspirations of the old nations of the north. Let us join forces and show our strength and unity of purpose in the acquirement of the knowledge that will prepare and fit us to press forward towards still higher ideals, and for that fuller conception of the continuity of well ordered science that shall assuredly make for Beauty, Goodness, and Truth, and for that culminating consummation of all

"One God, one law, one element,
And one far off divine event,
To which the whole creation moves."

ON A PITCHBLENDE PROBABLY OCCURRING IN NEW SOUTH WALES.

By T. H. LABY, B.A., Research Student of Emmanuel College, Cambridge, Joule Student of the Royal Society, formerly Exhibition of 1851, Research Scholar of the University of Sydney.

[Communicated by F. B. GUTHRIE, F.I.C., F.C.S.]

[Read before the Royal Society of N. S. Wales, June 2, 1909.]

LATE in the year 1904, the writer received a mineral from Mr. G. W. Card, A.R.S.M., to test for radio-activity. It was found to be so strongly radio-active that the activity could only be explained if radium were present in it. The mineral had been received with a number of others by Mr. Bennett of Newcastle, New South Wales, from his prospector. Some time elapsed between its receipt and Mr. Bennett's identification of it as a uranium mineral. This interval was sufficiently long to make the exact place where the specimen was found uncertain, but the most probable place was the New England District of New South Wales. Mr. Bennett himself prospected that district to rediscover the mineral, but I understand failed to do so.

Recently Mr. C. Poulot, a French metallurgist, saw six tons of what he is convinced is the same ore at a works in Germany. He was informed that it had been shipped from Melbourne as silver ore, and that two tons of good pitchblende had been obtained from it in addition to sulphides. If it is true that the ore was shipped from Melbourne, it does not seem probable that it was procured from New England.

The writer examined the radio-activity of the mineral, and made as complete an analysis of it as the 4 grams received in the first instance would allow. Some 10 grams more were received later, but too late for full use to be made of it.

Chemical Analysis.—The original fragments of the mineral were contaminated with gangue, which could be readily distinguished from the pitchblende. As much as possible of this impurity was removed, and the mineral was then coarsely powdered and the uncontaminated grains picked out. The gangue appeared to be lead sulphide. The density of the most homogeneous of the original fragments was found at 23° to be 7·3 gms. per cubic cent., and of the finely powdered material analysed 7·65. The small amount of the mineral received made refined and accurate analysis difficult.

The methods of analysis used are indicated in the following table, they are in the main those used by Hillebrand[1] in his very complete study of uraninites. UO_2 was determined by dissolving the mineral with dilute sulphuric acid in a closed tube; solution only took place after several days' heating at over 100° C. The iron present was reduced by H_2S. The uranium present as UO_2, and iron were determined by titration with N/20 $KMnO_4$; the iron was also found gravimetrically, and so the UO_2 could be deduced. The proportion of UO_2 to UO_3 is unusually small, I regret that I was not able to verify it by a second determination. The value for the content of uranium was checked. Rare earths were looked for by adding oxalic acid.

To about 2 gms. of finely powdered mineral digested on water bath with 30 cc. of 2·5 E HNO_3 and then with 20 cc. 4E HNO_3, to dryness: 2·5 dilute HCl added, evaporated to dryness, taken up with dilute HCl, filtered.

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[1] Bull. U.S. Geol. Surv., No. 78, 1891.

<table>
<tr>
<td rowspan="5">Insoluble and SiO_2 weighed: SiO_2 determined by H F and H_2SO_4</td>
<td colspan="5">Diluted filtrate to 400 cc., passed H_2S through hot solution.</td>
</tr>
<tr>
<td rowspan="4">PbS, CuS, Bi_2S_3, As_2S_3. Lead weighed as $PbSO_4$; Bi pptd. as BiOCl weighed as Bi_2O_3; Cu colorimetrically as a trace.</td>
<td colspan="4">Filtrate concentrated to 200 cc. by boiling 30 cc. 3E Am_2CO_3 + 10 cc. 15 E NH_4HO (excess must be avoided). H_2S passed through liquid when hot.</td>
</tr>
<tr>
<td rowspan="3">FeS, MnS, Al_2O_3?, ZnS?, with some CaO but no rare earths; precipitate roasted and weighed, Fe was separated by basic acetate method; Mn by difference.</td>
<td colspan="3">Evaporated filtrate nearly to dryness, dissolved the ppt. $(NH_4)_2U_2O_7$ and UO_2S in a minimum of dilute HNO_3. Added fresh NH_4HS digest for some time.</td>
</tr>
<tr>
<td colspan="2">Uranium, rare earths, and calcium: dissolved in HNO_3 evaporated to dryness; dissolved in water; oxalic acid added.</td>
<td rowspan="2">Magnesium, trace found.</td>
</tr>
<tr>
<td>No rare earths precipitated.</td>
<td>Added NH_4HO to precipitate the calcium and uranium; weighed as U_3O_8 + CaO. Dissolved ppt. and determined the CaO present.</td>
</tr>
</table>

To the neutral solution in two separate analyses, no indication of the presence of the rare earths was obtained. In the light of Hillebrand's analyses of uraninites and of Professor Strutt's work on the association of helium with uranium there can be no doubt that this mineral contains helium. I have no record of having determined the amount

of sulphur present, but it is very probable that some of the bismuth, copper, and possibly some of the lead may be there as sulphides.

UO_3	... ...	69·0 per cent.
UO_2	... ...	8·8
PbO	... ...	6·0
Mn_3O_4, ZnO ?	... ...	4·2
Fe_2O_3	... ...	2·7
CaO	... ...	3·7
Insol.	... ...	2·4
SiO_2	... ...	·1
Bi_2O_3	... ...	·4
CuO	... ...	·1
As_2O_3	... ...	trace
MgO	... ...	trace
H_2O at 130°	... ...	·69
		98·1

Density at 23°... ... 7·65 gm./cub. cent.

No rare earths detected.

Discussion of the Analysis.—If we compare the results of this analysis with one made by Hillebrand[1] of an altered and crumbled pitchblende from Johanngeorgenstadt in Saxony, we see in certain characteristics a close resemblance. The first analysis below is the one already given of the New South Wales mineral, the other is the Saxony mineral:

	S.G.	UO_3		UO_2			PbO	CaO	Fe_2O_3	H_2O
N.S.W.	7·6	69·0	+	8·8	=	76·8	6·0	3·7	2·7	·7
J.	6·98	59·3	+	22·3	=	81·6	6·4	1·0	·2	3·2

	CuO	Bi_2O_3	SiO_2	MgO	
N.S.W.	·1	·4	·05	tr.	tr. As_2O_3
J.	·17	·75	·50	·17	2·3 As_2O_5

[1] Am. Journ, Sc., XLII, 390 (1891).

The Saxony mineral contained also N(*i.e.* He), MnO, Na_2O, P_2O_5, As_2O_5, V_2O_5, WO_3, MoO_3, SO_3 in small quantities. Neither mineral contained rare earths.

The chief difference between the two pitchblendes lies in the greater density, and presence of less water in the New South Wales one. In these respects it approaches the crystalline uraninites—a brilliant and well-defined example of which was found by Hillebrand[1] to contain 13·3 UO_3 + 72·2 UO_2 = 85·5, ThO_2ZrO_2 7·2, PbO 4·3, H_2O ·7, S.G. 9·7. But the absence of rare earths, the presence of CuO, Bi_2O_3, As_2O_3, the high proportion of UO_3, and the massive and non-crystalline form of the New South Wales mineral indicate that it is probably a secondary pitchblende.

Radio-Activity.—The radio-activity of the mineral was measured by placing a uniform thick layer of it in the form of a powder in a flat circular lead dish between the plates of a condenser separated by 5 cms. of air. The ionization it produced with a saturation voltage was 3·15 times that obtained when the mineral was replaced in the lead dish by black oxide of uranium U_2O_5. Thus the radio-activity of the mineral is 4·4 times that which it would have solely on account of the uranium which it contains. McCoy[2] (who allows for the absorption of the α particles in the layer of radio-active matter which I did not do), has shown that for the uranium minerals he examined the above number is 4·15. The radio-activity above that contributed by the uranium is known to be due to ionium, radium and its products. Since this extra activity is slightly above its normal value, it follows that Bennett's pitchblende contains at the least the normal amount of radium for that variety of mineral. This was confirmed by comparing its activity directly with that of a Bohemian pitchblende—the New South Wales mineral was the more active by 1%.

[1] U.S.G.S., No. 78, p. 64 (1891). [2] Phil. Mag., Jan. 1906, p. 176.

The Economic Value of the Mineral.—Since it has the composition of a secondary pitchblende, it is to be expected that it may occur, as the other secondary ones do generally, in such quantities as to make its recovery payable. Moreover, it only contains such elements as are readily separated from one another by the methods used to obtain pure uranium and radium from Bohemian pitchblende.

Two other Australian minerals containing radium have come to the writer's notice. A monazite from Pilbarra, W.A., was shown by Mawson and the writer[1] to give off radium emanation when heated. Mr. Chapman,[2] noticed carnotite, a vanadate of uranium and potassium, in a sample of ore sent to him for analysis from the vicinity of Olary, S.A.; and Mawson discovered a new secondary mineral davidite, containing uranium, potassium and vanadium in the same ore. These South Australian minerals occur in pegmatite veins as do most of the uraninites. If further efforts are made to discover Bennett's pitchblende in the New England district, it would be most profitable to examine the pegmatite granites which occur there. Uranium minerals are undoubtedly most readily identified even in the field by their property of discharging gold-leaf electroscope, their action on a photographic plate, or the production of scintillations on a zinc blende screen.

I wish to thank Mr. Card for having obtained and brought to my notice the mineral I used in the experiments described above, and also Mr. Bennett, who placed what information he had as to the finding of it at my disposal. The writer carried out his investigation of the mineral in the Chemical Laboratory of the University of Sydney.

[1] This Journal, xxxviii, 1904, or Chem. News, July 1905, p. 39.
[2] Mawson, Trans. Roy. Soc. S.A., xxx, 1906.

THE VISCOSITY OF WATER.

By RICHARD HOSKING, B.A. (*Camb.*), Physics Master, Sydney Grammar School.

[Communicated by Prof. POLLOCK, D. Sc.]

[*Read before the Royal Society of N. S. Wales, June 2, 1909.*]

IN a paper on the above subject[1] read before this Society on June 3rd last year, I explained how I had obtained absolute values for the viscosity of water at three different temperatures. I have since examined my reductions more carefully, and have found that the values are, in c.g.s. units, ·*005500* at 50° C., ·*008926* at 25° C., and ·*017897* at 0°·05 C. The last value reduces to ·017928 at 0° C. Knibbs[2] has deduced the absolute value ·013107 at 10° C., from Poiseuille's observations, and has shown that the data of every other experimenter whose work was published earlier than 1895, including Thorpe and Rodger, were not satisfactory for absolute values. So far as I have been able to examine the work published since 1895, I have reached a similar conclusion with regard to it. In order, therefore, to obtain a complete table of absolute values between the temperatures 0° C. and 100° C., I have revised all my earlier work,[3] and reduced my observations for water by applying, in the reduction formula, as given in my last paper the values $n = 1·64$; and $m = 1·158$.[4] My results, obtained in this way, are collected in the following table. Each value is obtained by the reduction of double sets of observations.

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1 This Journal, XLII, pp. 34 - 56. 2 This Journal, XXXI, p. 319.

3 Phil. Mag., March 1900, May 1902, May 1904.

4 Boussinesq's theoretical correction is 1·12, but experimentally I obtained the average value 1·158 for four tubes which had been treated in exactly the same way as those used in these earlier experiments.

The table contains also the kinetic energy correction in each case. The values are reduced to even temperatures by means of the formulæ to be given later in the paper. These formulæ reproduce the observed values with remarkable closeness, and so the above method of reduction is justified.

Temp. ° C.	K.E. term × 10^6	Viscosity × 10^6	Reduction × 10^6	Viscosity at even Temperatures.	
0·10	6·5	1785	+6	·01791	·01793 at 0° C.
0·25	9·5	1780	+15	·01795	
0·21	11·0	1780·5	+13	·01793	
0·21	11·0	1779·5	+13	·01793	
5·71	7·6	1489	+33	·01522	·01522 at 5° C.
6·53	10·4	1452	+70	·01522	
9·89	11·0	1314	−4	·01310	·013105 at 10° C.
10·05	12·5	1310	+2	·01312	
12·44	11·9	1221	+87	·01308	
12·51	9·2	1223	+89	·01312	
17·07	9·9	1083	+59	·01142	·01142 at 15° C.
17·10	9·9	1082	+60	·01142	
20·37	11·2	997	+9	·01006	·01006 at 20° C.
20·44	11·2	998	+10	·01008	
20·72	14·4	989	+17	·01006	
20·72	14·4	988	+17	01005	
30·25	13·7	798	+4	·00802	·00800 at 30° C.
30·40	13·7	793	+6	00799	
30·78	17·1	787	+13	·00800	
30·78	16·0	786	+13	00799	
40·07	16·2	658	+1	·00659	·00657 at 40° C.
40·00	16·0	657	±0	00657	
41·74	19·3	636	+21	·00657	
41·74	19·3	635	+21	·00656	
50·10	18·4	550	+1	·00551	·00550 at 50° C.
50·30	18·9	548	+3	·00551	
51·82	21·2	533	+16	·00549	
51·82	21·0	532	+16	·00548	
59·90	18·4	468	−1	·00467	·00469 at 60° C.
60·13	18·3	470	+1	·00471	
60·67	23·0	463	+5	·00468	
60·67	22·8	464	+5	·00469	
65·30	21·0	434	+2	·00436	·00436 at 65° C.
65·38	21·0	434	+2	·00436	

Temp. ° C.	K.E. term × 10⁶	Viscosity × 10⁶	Reduction 10 ×⁶	Viscosity at even Temperatures.	
69·91	19·7	410	−0·5	·004095	·00406 at 70° C.
70·10	20·8	405	+0·5	·004055	
71·58	25·3	396	+9	·00405	
71·58	25·3	396	+9	·00405	
80·27	22·5	357	+1	·00358	·00356 at 80° C.
79·90	20·8	356	±0	·00356	
81·19	26·6	350	+5	·00355	
81·19	26·6	350	+5	·00355	
90·00	22·5	316	±0	·00316	·00016 at 90° C.
90·10	29·0	314	+1	·00315	
90·10	29·4	316	+1	·00317	
90·10	29·3	316	+1	·00316	
95·8	23·9	298	+3	·00301	·00300 at 95° C.
97·7	23·6	291	+8	·00299	
97·7	23·6	291	−7	·00284 at 100° C.	

These values agree so well with the four absolute values already mentioned, at the temperatures 0° C., 10° C., 25° C. and 50° C. respectively, that I feel justified in concluding that at the other temperatures also they may be taken as absolute values. When these results are compared with those of Poiseuille, Graham, Rosencranz, Slotte, Noack, and Thorpe and Rodger, as re-determined by Knibbs, it will be seen that their closeness to the mean values at the different temperatures as far as 50° C. is remarkable. The following table will give the values for the relative fluidities between 0° and 100° C., at 5° intervals; the fluidity at 0° C. being represented by 1000. My values at the odd 5° were interpolated by means of a graph. All the values of the other experimenters are those given by Knibbs in his paper.[1]

Table of Relative Fluidities 0° C. to 100° C.

Temp. ° C.	Poiseuille 1846.	Graham 1861.	Rosencranz 1877.	Slotte 1883.	Noack 1886.	Thorpe and Rodger 1894.	Average Values.	Hosking's Values.
0	1000	1000	1000	1000	1000	1000	1000	1000
5	1177	1183	...	1181	1178	1176	1179	1178
10	1363	1369	...	1372	1375	1365	1369	1369
15	1557	1580	...	1574	1575	1562	1570	1569
20	1771	1786	...	1785	1796	1772	1784	1782
25	1992	2021	...	2005	2020	1992	2006	2008
30	2226	2240	...	2233	2233	2225	2231	2241
35	2479	2493	...	2473	2484	2466	2479	2477
40	2738	2758	2730	2717	2726	2716	2731	2730
45	3010	3018	3020	2961	2974	2976	2993	2988
50	...	3308	3270	3214	3214	3246	3260	3260
55	...	3549	3540	3477	3479	3517	3512	3530
60	...	3834	3720	3744	3763	3797	3772	3823
65	...	4165	3980	4017	...	4086	4062	4112
70	...	4461	4210	4294	...	4385	4338	4414
75	...	...	4430	4571	...	4693	4565	4719
80	...	...	4620	4849	...	5003	4824	5037
85	...	...	...	5128	...	5316	5222	5352
90	...	...	5460	5409	...	5633	5501	5674
95	...	...	...	5695	...	5955	5825	5977
100	...	. .	...	5083	...	6282	6132	6314

It was found that my viscosity results could be very accurately represented by formulæ of the type $\eta_t = \eta_0/1 + k_1 t + k_2 t^2$, provided the range of temperature for each set of constants was not very great. Thus for temperatures 0° to 25°, the formula is

$$\eta_t = \frac{\cdot 017928}{1 + \cdot 03445\, t + \cdot 000235\, t^2} \quad \text{.........(1)}$$

for temperatures 25° – 50°,

$$\eta_t = \frac{\cdot 017928}{1 + \cdot 03544\, t + \cdot 0001952\, t^2} \quad \text{.........(2)}$$

for temperatures 50° – 75°

$$\eta_t = \frac{\cdot 017928}{1 + \cdot 0364\, t + \cdot 000175\, t^2} \quad \text{.........(3)}$$

and for temperatures 75° – 100°

$$\eta_t = \frac{\cdot 017928}{1 + \cdot 0390\, t + \cdot 000142\, t^2} \quad \text{.........(4)}$$

A single formula which represents the results over the whole range of temperatures is

$$\eta_t = \frac{9\cdot185}{(46\cdot694 + t)} - 1\cdot6232 \quad \ldots\ldots\ldots\ldots\ldots(5)$$

but the agreement between the observed values and those derived by this formula is not so good.

The following table gives the complete set of my values for the absolute viscosity of water, and also the values of Thorpe and Rodger as re-determined by Knibbs. It also contains the values computed by the formulæ already mentioned. I consider that my values are correct as far as the last figure given in each case.

Temperature °C.	Absolute Viscosity.	Viscosity (Computed).	Viscosity (Computed).	Thorpe and Rodger's Values.
0	·017928	·017928[1]	·017928[5]	·01778
5	·01522	·015218	·01520	·01512
10	·013105	·013107	·01308	·01303
15	·01142	·011422	·01143	·01138
20	·01006	·010055	·01005	·01004
25	·008926	·008926[2]	·008938	·00893
30	·00800	·00801	·00801	·00799
35	·00724	·00723	·00723	·00721
40	·00657	·00657	·00657	·00655
45	·00600	·00600	·00600	·00597
50	·005500	·00550[3]	·005500	·00548
55	·00508	·00508	·00507	·00506
60	·00469	·00470	·00469	·00468
65	·00436	·00436	·00435	·00436
70	·00406	00406	·00405	·00405
75	·00380	·00380[4]	·00379	·00379
80	·00356	·00356	·00355	·00355
85	·00335	·00336	·00333	·00334
90	·00316	·00317	·00314	·00316
95	·00300	·00300	·00296	·00299
100	·00284	·00284	·00280	·00283

LOPE DE VEGA.

By LAWRENCE HARGRAVE.

[*Read before the Royal Society of N. S. Wales, June 2, 1909.*]

I PROPOSE to deal with happenings in the Commonwealth of Australia about twenty years after Sir Walter Raleigh was spreading his cloak for Queen Elizabeth to put her foot on. The subject matter of this paper has been floating in my mind for many years, and I now only submit it to you because a photograph has appeared in the public press which would lead others to similar conclusions. The few facts communicated to you, with the assistance of others that may be forthcoming, may help to raise the veil that enshrouds the fate of Lope de Vega and his wife Mariana de Castro.

If you refer to "*The first Discovery of Australia and New Guinea*," by George Collingridge de Tourcey, you will find that in the year 1595, that is twenty six years after the termination of the Sarmiento-Mendana voyage, Mendana was sent out again with instructions to found a colony at the island of San Christobal in the Solomon Group; and from thence to make another attempt to discover the Great Southern Continent, the Java Maior. The fleet consisted of three large vessels and a frigate, and Lope de Vega commanded one of the larger ones. As it was intended to settle a colony, many took their wives with them, and amongst these was Mariana de Castro, Lope de Vega's wife.

They sailed from Callao on the 9th of April, 1595, and, after discovering the Marquesas, they sighted Santa Cruz on September 7th of the same year. The frigate was ordered to sail round this island to search for Lope de Vega's ship which had parted company some time previously.

They thought that she might have passed to the north, but hopes of seeing her again were very faint, and the frigate returned to Mendana without any tidings of Lope de Vega. On September 21st Mendana found a port at Santa Cruz, which he named La Graciosa, and made an attempt at colonization, but what with the hostility of the natives, sickness, and a mutinous spirit, the colony did not progress, and here Mendana died.

You will observe there was a mutinous spirit, at which no surprise need be felt as Mendana was an old man and had obviously kept the fleet jogging along in about 10° S. Latitude: Callaŏ 11° 50′ S. Lat., Marquesas 8° 53′ S. Lat., Santa Cruz 11° 0′ S. Lat. Making 115° of Longitude with a brisk S.E. trade wind on his quarter, and crowds of young Spaniards on board spoiling for the sack of the Great Southern Continent. Make no mistake about the young Spaniards of Peru. They were the second and third generation of the conquerors who slew Atahuallpa, crossed with the best women of the Inca race. Garcilasso de la Vega came to Peru with Pedro de Alverado. His son, who subscribes himself Garcilasso Inca de la Vega, and was born at Cuzco in 1540, was the historian. The historian's mother was of Peruvian blood royal, she was niece of Huayna Capac and grand-daughter of Tupac Inca Yupanqui. Then there was Vaca de Castro, who went to Peru to appear before Pizarro in the capacity of a royal judge. Prescott has much to say of the doings of these people, but all of it points to everyone on Lope de Vega's ship being dark beyond swarthiness. What efforts must have been made to get Mendana to luff, but all were of no avail. However, sometime previously to the discovery of Santa Cruz, Lope de Vega parted company.

If this had happened in 160° W. Longitude, New Zealand might have been found, but we know it was not, or it

would be recorded in Maori song and dance. If in 170° W. Longitude, Samoa and Fiji would have occupied the attention of the wanderer. If in 170° E. Longitude, the New Hebrides and Caledonia would have been investigated. But if the parting took place in 9° S. Latitude and 180° Longitude, they would clear the Isle of Pines with a spanking trade wind and make a landfall at Port Macquarie, as hundreds of south sea traders have done since. Can we not see the picture at sunrise one bright November morning in 1595? The land as far as eye could reach to north and south. Can we not hear the shout "Te Deum laudamus, te Dominum confitemur"? Hark! The blaring of the trumpets. The throbbing of the alligator drums.

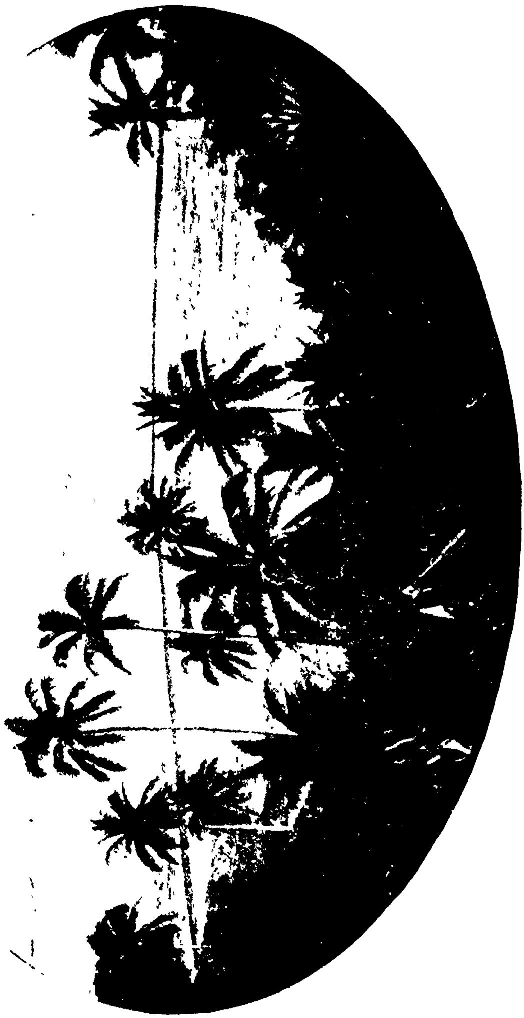
Here they would fall into the usual spring routine of north-easters and southerly bursters which have existed since Australia was, and which would enable them to visit all the coast to Cape Howe, and call it sombre, barren and goldless. If Sydney was visited and described or charted, North Head and South Head would be shown as islands. It is sufficient to indicate the sand dunes between Bondi and Rose Bay. The oldest one is that on which the Golf Club-house stands. The second one had its growth stunted by the Old South Head Road passing along its crest. The third one has been formed within the last few decades. Retracing their steps, Sandy Cape would appear to be the northern limit of the Great Southern Continent, but a few hours sail to the westward would pick up the land again, which of necessity they would follow by the Inner Route, wondering as they went further how they were going to beat back. Arriving at Raine Island and seeing the open ocean, they would gladly avail themselves of the passage, and coasting the outer edge of the Barrier, get embayed near Murray Islands, where so many other ships have left their bones. There was nothing for it but to rush the

them to any expedient to perpetuate their memory and attract the attention of those they knew would seek them. One of these was the making of tortoise-shell masks and head pieces in mimicry of their appearance, which their descendants were taught to use in innocent dances, singing the praise of those that brought the cocoa-nut, with words to this effect:—"Read! O read our story! we only act and tell the deeds of our ancestors; each mask is not a god, but the likeness of one of those who gave us knowledge." Bear in mind the probability that less than six of the ship's company could either read or write. Nothing so much as his unfortunate name has tended to destroy De Vega's relics. When visitors see the masks and dancing, they ask "What is this?" and the natives answer '*Devega-Devega*.' The visitor notes it down '*Devil-Devil*,' and this is the name now used in the Straits for masks. And masks and all connected with them, are, and have been, long under the bann of zealous evangelists, and marked for ruthless destruction. The masks of to-day made of green turtle shell, grass, feathers, etc., may bear as much likeness to the De Vega masks, as our toyshop masks do to Guy Fawkes, and but serve to accentuate the truth that human nature is world wide in its methods.

A lump of silver coins has been found near Murray Islands, but I have not heard if they have been separated, and the impressions on the inner ones inspected. This is probably one man's purse. The ship's gold is in a safe place. In April or May 1906 two ancient brass cannon were also recovered, which have a story to tell.

The ruck of the ship's company would remain at Murray Islands, and any others of a superior nature must have passed on to and settled at Darnley Island (Eroob) as masks existed there when Sir William Macleay and Capt. Onslow visited the place in the '*Chevert*.' I was on the '*Chevert's*'

articles as engineer and know the row there was about the rape of a mask, and how it had to be restored to its owner. Englishmen also own heirlooms that money will not buy.



PREHISTORIC FISH TRAP AT DARNLEY ISLAND.
Lope de Vega, Engineer, 1599. Eroob men made it.

There is also an extensive fish trap or turtle pond here of which a picture is shown in "*Sydney Mail Annual*," Oct. 3,

1908. Lope de Vega's house was somewhere near where the camera stood, so placed that he could see if people came to steal his turtle. This work is far beyond any conception of a native mind, but is well within their united power to construct when directed by a Spanish head. It is also a work that no sheller or beche-de-mer fisher would be at all likely to make or encourage others to make.

At Stephen's Island (Ho-gar), a little further on, I think one, if not the last of the pioneers died. When I was there in December 1877, and walking round the north end of the island, I saw a small hut, little larger than a dog-kennel. My curiosity was aroused, and I pulled aside the pandanus leaves that hung across the front of it, and saw a long object lying on some dry palm leaves. It was about 18 inches by 4 inches diameter. This was covered with the brown gum the natives secure the barbs on their arrows with, and a number of jecquerity seeds (*Abrus precatorius*) were stuck in the gum. A native came out of the scrub with signs of fear at my proceedings. I calmed him, and he saw I meant no harm; we sat down and in the gibberish of the Straits tried to understand one another. This is the translation I made and entered in my notes at the time:—

"There is a valuable curiosity on Hogar, it is in a small hut by itself on the north side of the island, it has been watched with jealous care by three generations of a man called Ma-te. It is death for a woman or beardless boy to look at it. The custodian has to visit it daily without clothing or arms. Sundry skulls are around that were taken by an ancient Papuan man whose name I could not catch. Ma-te told me not to tell the missionary as he would steal it. He said I was the first white man who had seen it."

It is obvious enough to me now that Ma-te was not the man's name, but Muerte (Spanish for death), and the three

generations meant very ancient. Had I been the last survivor and had nothing left but half a helmet full of musket balls and the chart and log of our ship, I should have been able to preserve my treasures to show my King how faithfully I had carried out the trust reposed in me, and Lope de Vega could do the same and they would be perfectly safe for 1,000 years. I should have made a cylindrical hole in the sand with a piece of bamboo, and stood a smaller stick in the centre of the hole; then melted the lead in the helmet and poured it into the annulus. The treasure would be placed inside the lead pipe thus cast, and the ends hammered up tight with a stone. I should have covered it with the gum so as not to attract the cupidity of the natives, told the guard to stick a red seed in the gum with much ceremony and hold a turtle feast at the return of every N.W. season, keep the little hut in repair and pass the word on to his successors, and a very large reward would be given for an apparently worthless article. The Spanish word 'Muerte' is extremely well selected.

When the brass guns were found in 1906, I wrote to the Rev. E. Baxter Riley, asking him in the course of his rounds to obtain this curio and forward it *intact* with every scrap of information as to its origin that the natives possessed and I would pay all expenses; and authorized him to pay guns, knives, axes, or anything in his store, and if he had not got what they wanted, it would be sent from Sydney. In due course Mr. Riley went to Hogar and ascertained from the teacher there, and the oldest inhabitant, that the little hut and its contents, which the teacher called a god, had been burnt about 20 years ago. (Note, no trifling thing would be remembered 20 years). The teacher with the consent of the people, set fire to the place; there was great difficulty in getting the people to talk about Ma-te. I am quite familiar with the obscene little figures it is

usual to call gods, but know the object I wanted could not be mistaken for one of them.

In April 1907, Mr. Riley said that after he left Hogar, an old woman said the contents of the hut were removed and buried before the building was burnt. The natives had turned up the ground all round the site, in places to a depth of three feet, but found nothing. I then requested Mr. Riley to open and minutely inspect anything the natives brought him, so that I should not be imposed upon by a trumpery imitation, as the natives knew the appearance of what I wanted and could make another to suit the occasion. In October 1907, a great part of the island had been turned up with no result.

The reason Hogar was selected as the proper place for the hut and its contents, when most if not all the Spaniards lived at Murray or Darnley was that in August, September, or October 1606, Torres after leaving Orangerie Bay, New Guinea, passed within gunshot of Hogar, even if he did not anchor there. The news would soon pass to Murray Islands, even if De Vega did not himself see the ships from Darnley. Where is the sheller who cannot picture the Eroob man speeding to the eastern shore, where De Vega lived, with the tidings; the rush for a canoe; the wild sail in chase; the splashing outrigger; the mat sails: the baling and assisting paddles; the widening distance till off Nahr-ge (Mount Ernest) hope vanished and the ships disappeared towards Moo-re-lug (Prince of Wales); the landing at Nahr-ge; the sympathetic cries and condolences of the people at the disappointment and despair of their friend De Vega?

After this, a short canoe voyage would make it certain that the Fly River rollers and Warrior Island reef, and the position of the eastern reefs and Bramble Cay, rendered the passage of Torres Straits impossible except by the N.E.

channel as shown in our charts to-day. Torres might have wished to visit the high island to windward (Darnley Island) but the wind was certainly contrary and he did not know the set of the tides.

When we were at Darnley Island in the "*Chevert,*" we tried to find out things about New Guinea, pointing to the N.W. and using the words Papua, Fly River, and New Guinea, which of course the Eroob men did not understand; they used Dow-dai, meaning what was to the N.W., and we took it to be the name of the country. Then you observe the guard of the Hogan curio said, according to my translation, that the skulls around were taken by an ancient Papuan, using the words Dow-dai man. Now we know there is no place called Dow-dai to the N.W., there are Mar-wot-ter, Tu-re-tu-re, Bo-bo. Yar-row (now called Da-ru) Ke-wi etc. If we take Dow-dai to be a well-remembered man's name, we have a most probable story, to wit. De How-di or De Owdi, a shipmate of De Vega, left Darnley Island, travelled in the direction of Manila viâ Hogar and the Fly River, and never returned. The north coast of New Guinea was previously known in Peru. I have asked Mr. Collingridge if it is possible for him to tell me if there was a De How-di with De Vega. Mr. Collingridge has found no such name.

Here it is proper to mention the intrusion of tobacco smoking among the chewers of chunam, and the not inconsiderable tradė in tobacco. Tersely, Coo-ber-re tobacco is highly esteemed at Han-nu-er-par-ter (Port Moresby). Coo-ber-re bears N.W. from Port Moresby. Oo-ber-re tobacco is well known at Mar-wot-ter. Oo-ber-re bears north from Mar-wot-ter. Tobacco is brought down the Fly River by canoe; I pirated a sackful on the Fly River. Coo-ber-re tobacco is taken to Port Moresby from the head of the Gulf in the lack-er-to-es on their annual trading voyages.

Also on Monday, July 17th 1876, I wrote . . . . "to the first village on the S.W. end of Ke-wi . . . . there is a scientifically constructed trestle bridge, forty yards long and fifteen feet high across a swampy creek . . . . they use the Pandean pipes." It is not likely that either of these ideas originated from their interviews with Captain Blackwood, or from Birmingham trade articles.

The clue to the whole riddle is still within our grasp. At page 193, Jukes' *Voyage of the "Fly,"* is a woodcut of a tortoise shell figure, and Juke says, at Darnley Island "Mammoos would go on board with me taking a large tortoise shell figure of a boy, three feet high, and very curiously constructed, for which I had no room, but which he sold to Mr. Bell for an axe."[1]

You see even Jukes noticed this figure is '*very curiously constructed.*' No Torres Straits natives boil and bend tortoise shell to the shapes they want. The proportions of the figure are half size and more accurate than an ordinary sailor would make even now. The material chosen, tortoise shell, when pieces of iron armour were in his possession, shows great forethought. Tortoise shell is the commonest sheet material, and would not excite the cupidity of the natives. Iron would court destruction for use as knives

[1] It is now in the museum of the (now Royal) United Service Institution.

or scrapers. See the shape of the crest, right and left hand sides the same. The marking round the brow of the helmet, the knight's motto or name, probably DEVEGA. The Greek key scroll work shown in the wood-cut is impossible in the original, and is a substitute of some dour Christian who thought it hellish even to write DEVIL even if the small size of the woodcut did not preclude it. If this surmise is correct, how many men have been put off the the scent by this inaccuracy. See the portion of Elizabethan period ruff on the left shoulder of the figure; the shoulder guards to protect the neck when the helmet is not rigidly united with the breast plate. The sword belt of small cowrie shells; if the figure represented a native, this would be round the neck. The figure is damaged on the left side, the shoulder guard broken off and the GA effaced at the same time. See the black moustache, (Jukes calls the figure "a boy") no Straits natives have that. The right hand beckoning for aid, or perhaps holding a sword.

If the body is made of bamboo, the head pulls off and the neck is the stopper and contains the screed. Dampier preserved his journal in a joint of bamboo. The joint of bamboo on the table before you would fit this three feet figure's body. See the end of it showing between the legs of the picture.

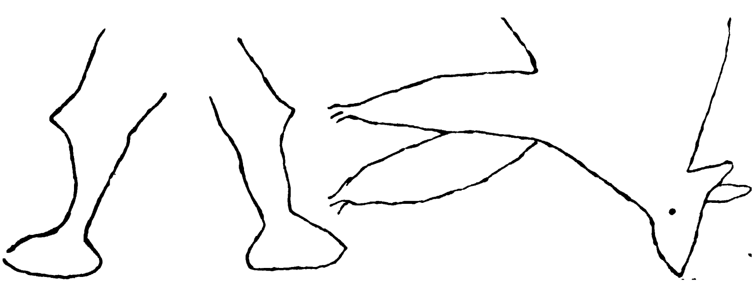
Note how well De Vega's memory was cherished, 250 years, and the instructions carried out; Mammoos, a descendant, *would* go on board the "Fly" and personally deliver his charge to the first big canoe that came there. Mama, is Peruvian for mother.

The Royal United Service Museum now contains only Naval and Military relics. In 1896 the British Museum purchased objects from the United Service Museum; there was no tortoise shell figure, in fact nothing from Darnley

Island among them. The curator, T. Athol Joyce, says, "Probably Jukes' figure fell to pieces through neglect, or disappeared when the other ethnographical objects were moved here." The first probability is very unlikely, as the rigid right arm betrays strength and solidity of structure, the second probability and the uniqueness of the object lead me to hope it now forms the most cherished relic in a private museum, and that its present owner will, from *national interest in the fate of a bold seaman*, tell us the secret that reposes in Lope de Vega's heart. If I read this riddle with any approach to the truth, what scenes of wild adventure and pathetic grief took place in this silent corner of our globe, where human nature ruled, untrammeled by the greed of gold and dread of hell.

It is hoped that any who can, will generously supply incidents and relics that will help to fill up missing links. It does not matter in the least if they are in the *highest degree contradictory*, these things have a way of straightening themselves out as all history shows.

Postscript.—The rock carvings in the vicinity of Sydney taken in connection with that most interesting drawing by Mr. George Collingridge showing "*the oldest known chart of Australia and a modern one compared*," and also the subject matter of this paper, induce me to make these deductions as to their origin, without previously ascertaining the views of others. For the purpose of this paper, I speak only of parts of a figure of a kangaroo and another



near it of a man. Both are within a few yards of my front door, and in all probability will soon be reduced to spawls. Some of the rocks near have a thin coating of earth, lichens and scrub that should be cleaned up and any markings preserved.

If we say the work was done by the aborigines of Australia, we have to assume they had a knowledge of metallurgy sufficient to make a gad or point tool of bronze, copper or iron which was struck with a maul or hammer; a knowledge of perspective, as shown in the kangaroo's left paw and ear, and also a knowledge of sabots and a pointed covering to both knees as shown in the man. There is also a large ruff or collar and a mark or scar in the middle of the forehead. The left hand is cut in the same conventional manner as that of the tortoise shell figure from Darnley Island. The man is short and sturdy, and we must find a reason for industry with no apparent object. If we say an escaped convict made these carvings in their exposed position for mere amusement and to betray his whereabouts to the gaolers, we state an absurdity. If an assigned servant made them at the bidding of his master, we want a reason for the order. The occupations of the free colonists and the soldiery were of such a character that they need not be suspected of delineating the figures.

I cannot see any better reason for the existence of these markings than to say that they were made by Peruvian slaves at the command of their Spanish masters. The search for gold brought the Spaniards west from America. The Spaniards did not quarry rocks and wash sand themselves in Peru. They brought slaves to work the ship, and dig for treasure as they had long been accustomed to do in the Andes with copper picks, gads and mauls.

Let me draw a word picture of the scene as it appears to me:—Lope de Vega's ship comes booming down the coast

before a north-easter. They reach North Head and see the port. They shorten sail, a boat is launched and goes ahead to sound. The ship follows, past South Reef, and Sow and Pigs (then a rock about as big as Pinch-gut) and Shark Point, anchoring in Rose Bay, off "Carrara." The empty water casks are filled at "Tivoli." A prospecting party, armed, lands on Point Piper and extends its search as far as Botany. They return goldless, bringing a great animal of curious form, and cast it on the rock. They signal for a boat. The clumsy shallop makes slow way against a southerly, the crew urged on by scourge and blow. The shape of the animal is scribed round, the miners are told to work round the line with gads. Others sitting idle are made to work at a figure of a Spaniard in armour, and other things. Can you see it thus?

Mr. Charles Hedley, F.L.S., has since shown me Memoirs Geological Survey, N.S. Wales, Ethnological Series, No. 1, 1899, by W. D. Campbell. This contains many more figures, two of which show the pointed knee covering, and also numbers of fishes. The point tool is noticed in the work. There are too many carvings to be all attributable solely to Peruvian miners, but we can well understand the bleeding loading slave dropping his gads in the grass at every chance, and the sharp-eyed aborigine finding every one of them and mimicking their use.

CONTRIBUTION TO THE EXPERIMENTAL STUDY OF THE LARGE IONS IN THE AIR.

By S. G. LUSBY, M.A.

(Communicated by Professor J. A. POLLOCK, D. Sc.)

[*Read before the Royal Society of N. S. Wales, June 2, 1909.*]

1. Introduction.—In addition to the well known small ions naturally present in the air, with a mobility of about 1·5 in practical units, M. Langevin[1] has discovered others whose mobility is only of the order of 1/3000. M. Langevin calls these the 'large ions' of the air, and finds that their number under natural conditions considerably exceeds that of the small ones. Few particulars of these slowly moving ions in connection with the ordinary ionisation of the air have as yet been published; I give here some observations of their mobility, of their absorption by hygroscopic substances, and of their rate of reproduction, the results being the outcome of experiments carried out a little time ago at the Physical Laboratory of the University of Sydney.

2. The mobility of the ions.—The apparatus used in the experiments, which will be referred to as the testing pipe, is similar to that employed by Professor Zeleny[2] in his determination of the mobility of the small ions; it consists of a long brass pipe through which a steady stream of air is passed, the pipe being provided with an axial electrode. The electrode is divided into two sections insulated from each other; the portion at the mouth of the pipe, 3·6 cm. long, is earthed; the other part 156 cm. long is connected to a pair of quadrants of a Dolezalek electrometer. The

[1] Langevin, C. R., t. 140, p. 232, 1905. Le Radium, 4, p. 218, 1907.

[2] Zeleny, Phil. Trans., A. 195, p. 193, 1900.

length of the brass tube and of the inner rod is 160 cm., the inside diameter of the pipe 3·44 cm., and the diameter of the rod 0·69 cm. When the positive terminal of a battery is attached to the tube, the other end being connected to the earthed quadrants of the electrometer, the positive ions in the pipe travel towards the rod, the negatives to the tube, and vice versa if the tube is negatively electrified. With an instrument of the dimensions given, all the large ions of one sign entering the apparatus can be forced to the inner electrode with convenient values of the voltage and of the air stream.

An experiment to determine the mobility consists in taking a series of observations, with an appropriate air stream, of the ionisation current between the tube and the inner rod, for increasing values of the potential of the tube, until the current becomes constant. From such a series of measures the minimum potential for which the current has its constant value may be found, and the mobility calculated by the method developed by Professor Zeleny (*loc. cit.*). Owing to the variability of the number of the ions in the air under natural conditions, only a few such series of observations are accordant enough for the purpose of determining the mobility, and the investigation is consequently tedious.

The air used was from the compressed supply of the laboratory which is fed by a Sturtevant blower; before reaching the testing pipe it passed through several metres of 1 inch iron piping, the source of the supply being the air of the laboratory workshop. The humidities were determined from the readings of the wet and dry bulb thermometers.

The results which have been obtained are given in Table I., the mobilities (k) being velocities in centimetres per second due to an electric force represented by a potential

gradient of one volt per centimetre. The mobilities are given as calculated by Zeleny's formula without any corrections. In the investigation no leak was observed with zero air stream.

Table I.

Date.	Temperature.	Pressure.	Relative Humidity	$1/k+$	$1/k-$
1905					
Oct. 6	23° C.	756	76%		2856
„ 13	25	765	59	2833	
Dec. 7	26	771	68		2796
„ 8	25	768	78		2916
„ 21	24	766	55		2901
1906					
Jan. 22	23	761	72	2836	
Feb. 12	20	755	68	2524	
„ 15	23	760	76	2678	
Ap. 28	23	767	64	2565	
„ 28	23	767	64		2476

3. Absorption of ions by hygroscopic substances.—When air flows over hygroscopic material both small and large ions are absorbed. To get some idea of the magnitude of the effect, observations have been made of the percentage reduction in the number of ions, and of the percentage of moisture absorbed when the air stream is passed over calcium chloride and over phosphorus pentoxide before entering the testing pipe. The calcium chloride was used in a glass tube and the phosphorus pentoxide in an iron tray. The tray had a base 30 × 22·5 cms., divided by partitions which forced the air to flow over the whole surface of the drying agent, and was provided with a cover the edge of which dipped into a mercury seal so that the phosphorus pentoxide, when spread over the bottom of the box, could be quickly protected from the moisture of the outside air. The air stream flowed over the surface of the pentoxide

without mechanical filtration, the depth of the stream being 0·5 cm. The drying agents were tested for any ionising action on air in contact with them, but without any effect being detected.

The percentage of moisture absorbed during the passage of the air over the hygroscopic material, was estimated from the results of independent experiments giving the amount of water absorbed by phosphorus pentoxide, in test tubes in series, from the air as it emerged from the testing pipe. The percentages of moisture absorbed, given in Tables II and III are calculated on the assumption that the air was 'quite dry' after passing the final test tube.

The percentage reduction in the number of ions was determined by measuring the ionisation in natural air, and, immediately afterwards, in air, from the same source, which had passed over the drying agent. For the experiments in connection with the small ions the shorter section of the electrode of the testing pipe was connected to the electrometer.

Table II—Absorption of small ions.

Absorbing Material.	Percentage of moisture absorbed on assumption previously stated	Percentage reduction in number of ions. +	Percentage reduction in number of ions. −	Number of trials.
$CaCl_2$ in tube	50	29	29	6
P_2O_5 in tray	96	50	50	4

Table III—Absorption of large ions.

Absorbing Material.	Percentage of moisture absorbed on assumption previously stated.	Percentage reduction in number of ions. +	Percentage reduction in number of ions. −	Number of trials.
$CaCl_2$ in tube	50	24	29	12
P_2O_5 in tray	96	46	46	6
P_2O_5 in tray + two test tubes	'quite dry'	56	55	3

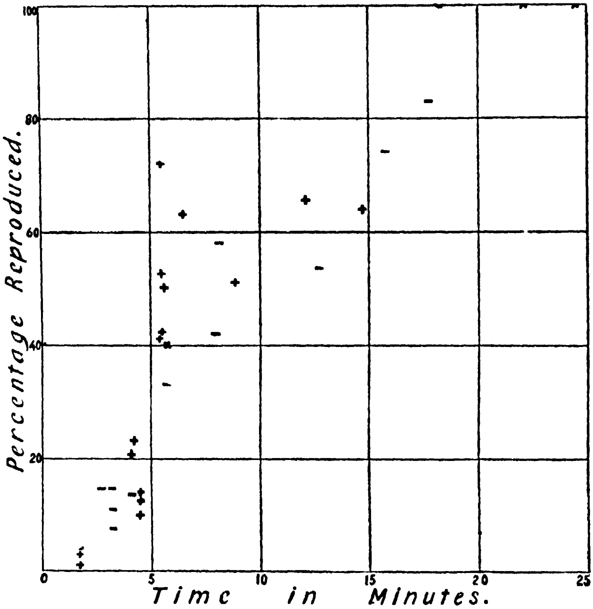
The results show that by passing air over hygroscopic material the ionisation is reduced to an extent which depends on the amount of moisture absorbed, though it was not found possible to remove all the ions from the air in this way.

4. Rate of reproduction of the large ions.—When two similar testing pipes are placed in series, separated by a length of earthed tube, if a potential difference is set up between the first pipe and its inner electrode just sufficient to force all large ions on to the inner rod for the air stream used, then any large ions detected in the second pipe must have been reproduced in the interval of time required for the air to travel from one pipe to the other. Observations have been made with such an arrangement using different lengths of brass tube between the two pipes. Finally, to increase the interval still further, two galvanised iron tubes each 2·25 metres long and 7·5 centimetres in diameter, were employed. For intervals up to two minutes the air, in its passage from the one testing pipe to the other, was in contact with brass; for intervals greater than this with a surface of zinc, and the rates of reproduction observed include any effect due to the metal within which the air was contained.

As the number of large ions in the air is very variable, it is not to be expected that the rate at which they are reproduced will be constant. The observations, indeed, of the interval required for the reproduction of a given number of ions per unit volume at different times are wholly erratic. The measures may however be treated in a different way, and the relation between the time given for reproduction and the number of ions produced, expressed as a percentage of the number originally present, is shown in Figure 1. The results of this method of reduction, though very variable, show some approach to regularity and it is

not perhaps unreasonable to think that the greater the number of ions in the air at any time, the greater will be the rate of reproduction if those present are removed. In the figure the observations with positive and with negative ions are distinguished by the usual conventional signs.

Figure I.



The relation between intervals of time from the removal of all the large ions and the number of ions, expressed as a percentage of the number originally present, reproduced in the intervals.

The observations indicate that if all the large ions are removed from the air at any moment, the number per unit volume will gradually increase with time, until after an interval of the order of 22 minutes it will be equal to that of the ions originally present.

For help with the earlier measures of the mobility I am indebted to Mr. J. Ewing, B Sc.

THE MOBILITY OF THE LARGE IONS IN THE AIR.

By J. A. POLLOCK, D.Sc.
Professor of Physics in the University of Sydney.

[*Read before the Royal Society of N. S. Wales, June 2, 1909.*]

1. Introductory.—The feeble mobility of the large ions in the air, discovered by M. Langevin[1] in 1905, indicates that their structure is somewhat complex. In this connection the idea must have occurred to many, and is indeed suggested by Professor Rutherford in his book on Radioactive Transformations, that these electrified entities may consist of water vapour molecules collected round small ions, a notion which seems to receive support from Mr. Lusby's[2] observation that they are absorbed by hygroscopic substances. The suggestion is strengthened by the results of the experiments to be described in the present paper, which were undertaken to find if the mobility of these slowly moving ions depends on the humidity of the air. The observations show that a definite relation exists between the two quantities, and incidentally, that if the humidity considerably alters the ions are not in equilibrium with the new vapour pressure conditions until after the lapse of a few minutes.

For help and encouragement derived from a discussion of the results during the progress of the work I am greatly indebted to Mr. William Sutherland of Melbourne; I wish also to acknowledge the great assistance I have received from Mr. Carl Sharpe of the laboratory staff, both in connection with the setting up and working of the apparatus and with the observations.

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[1] Langevin, C.R., t. 140, p. 232, 1905.

[2] Lusby, This Journal, p. 55.

2. Experimental detail.—The apparatus used in the experiments, essentially a cylindrical air condenser in which the leak between the electrodes is measured, is similar to the instrument used by Professor Zeleny[1] in his investigation of the mobility of the small ions, and to the arrangement employed by M. Langevin (*loc. cit.*) in his original determination of the mobility of the large ones. It consists of a brass tube, 164 centimetres long, provided with an axial electrode of the same length; the diameter of the inside of the tube is 3·65, and that of the inner rod 0·66 centimetres. The inner electrode is divided into two sections insulated from each other; the portion at the mouth of the tube, 3·7 cm. long, is earthed; the other part, 160 cm. in length, is connected by a fine wire, fitted with a guard ring, to a pair of quadrants of a Dolezalek electrometer, the whole of the apparatus being thoroughly protected from electrification due to external causes. The brass tube with its inner electrode will be referred to as the testing pipe.

Through the tube is passed a steady stream of air from the compressed supply of the laboratory, which is fed by a Sturtevant blower worked by a motor and storage cells. The stream is measured by a gas meter, and has been in these experiments of the order of 55 cubic centimetres per second. In our experience the ionisation seems more uniform if the air, before being used, passes through some length of tubing, and in this investigation the air travelled through several metres of 2·5 centimetre iron piping before reaching the testing pipe, the source of the supply being the air of the laboratory workshop.

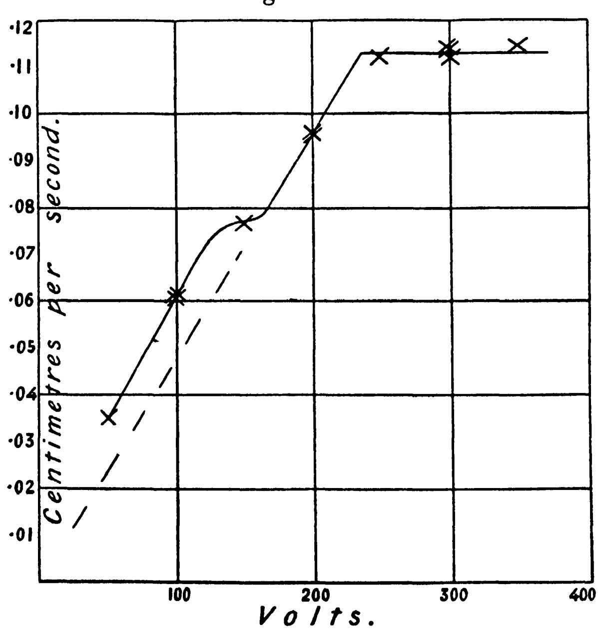
The tube is electrified by being attached to one terminal of a battery of small accumulators, the other end of the cells being connected to the earthed quadrants of the elec-

[1] Zeleny, Phil. Trans. A., 195, p. 193, 1900.

trometer. In some cases a leak, with zero air stream, has been observed in the opposite direction to that of the ionisation current; this is due to a falling cell voltage, the experimental arrangement being a very sensitive one for detecting changes in the battery potential. By not using the cells too soon after they have been charged the leak may generally be avoided.

The calculation of the mobility involves a determination, for the air stream used, of the minimum potential difference between the tube and its inner rod for which the ionisation current has a constant value. This critical potential is found from the plot of observations of the currents with increasing values of the potential difference, but, as the number of ions naturally in the air is usually very variable, it is only on occasions that the observations are accordant enough for the purpose of the investigation.

Figure 1.



In order that the form of the curve giving the relation between the current and the potential difference may be realised, I give in figure 1 the plot of observations, taken on an occasion when the measures were accordant over a fairly wide range of voltage, which shows the characteristics of the results obtained.

In the curves there are two critical voltages; the lower one may be interpreted in terms of an apparently new ion with a mobility of the order of 0·01 in practical units, all reference to which is reserved for a later paper; the upper one, giving the minimum potential for which the current has its constant value, represents the voltage when all the Langevin large ions entering the pipe are just caught by the inner rod. If V represents this critical potential, the mobility is calculated by the well known formula given by Zeleny *(loc. cit.)*, $k = \dfrac{\log_e b/a\ Q}{2\pi\ V\ X}$,

where b/a is the ratio of the diameters of the tube and of the inner rod, Q the magnitude of the air stream in cubic centimetres per second, and X the length of the inner electrode.

In Table I is shown the evidence on which depends the form of the curve just given. For a single determination of the ionisation current the order of the observation is as follows:—(1), reading of the gas meter; (2), repeated measurements of the reciprocal of the ionisation current in seconds per centimetre of scale reading; (3), determination of the leakage current with zero air stream. In the great majority of cases the leak immediately after the air stream was cut off has been zero; where a leak has been observed the measures have been corrected for it. In the table the positive sign attached to the observation means that the leak was in the same direction as that of the ionisation current.

Table I.

1908, March 26.	Air stream cc. per sec.	Volts.	ELECTROMETER. Secs. per cm.	Mean.	Corrected reciprocal cms. per sec.
a.m. 9·55	48·8	50	21, 23, 24, 22, 20, 21, 22.	22	·0350
	0		+ 95		
10·15	49·7	100	15, 15, 15, 15·6	15·1	·0609
	0		+ 187		
10·30	48·8	200	10, 10, 10, 10,	10	·0960
	0		+ 250		
10·55	51·5	300	8·8, 8·4, 8·4, 8·2,	8·45	·1143
	0		+ 250		
11·20	50·6	300	8·4	8·4	·1140
	0		+ 200		
11·30	51·5	350	8·6	8·6	·1145
	0		+ 560		
11·45	51·5	300	8·2, 7·8, 8·6, 8·2, 8·4, 8·4.	8·6	·1118
	0		+ 225		
12·0	51·5	250	8·6, 8, 8·8, 8·8.	8·55	·1118
	0		+ 196		
12·10	51·5	200	10, 10, 10·2, 10, 10, 10.	10	·0955
	0		+220		
12·30	50·6	150	12·2, 12·2, 12·2.	12·2	·0764
	0		+ 180		
12·45	51·5	100	14·2, 13, 14, 13·8, 14·4	13·9	·0625
	0		+ 106		

3. The mobility of the large ions.—To reduce the humidity, the air, before entering the testing pipe, was passed through tubes, five centimetres in diameter, containing calcium chloride. The humidity of the dried air was determined by a series of independent measurements giving the amount of moisture absorbed by phosphorus pentoxide from the air as it escaped from the testing pipe, the strength of the air eam being the same as in the experiments for finding the mobility. It is impossible to observe the humidity in this way for each determination of the mobility, and for each set of circumstances a result has been calculated from

the humidity experiments for the average of the values of the meteorological conditions which existed during the mobility observations. Owing to ionisation being caused by phosphorus it is not advisable to use phosphorus pentoxide as the material to dry the air in the first instance; when it was employed as in some cases the values of the mobility obtained were abnormal.

The first experiments with dried air showed little or no reduction of mobility. In searching for an explanation it was thought that perhaps when the humidity was changed the ions did not at once reach a state of equilibrium with the new vapour pressure conditions; the air after flowing over the calcium chloride was therefore passed through galvanised iron pipes before being directed into the testing pipe, as in this way the time between the drying of the air and the measurement of the mobility could be varied. In the first part of Table II are given the values of the mobilities of the ions at the end of different intervals of time after the air had been in contact with the hygroscopic substance, the humidity being sufficiently constant for the purpose of the comparison. The positive and negative signs in the table indicate the class of ions to which the respective observations refer.

The mobility decreases as the time increases from the moment of contact of the air with the drying material. In the case given the minimum value seems to be reached in about 7 minutes; in all succeeding experiments an interval of 13 minutes was allowed to elapse between the drying of the air and the determination of the mobility of the ions.

In the latter part of Table II are given the further results against which nothing is known. In many cases observations have appeared normal, but owing to a change in the ionisation were unable to be repeated; only those results have been retained which depend on experiments

Table II.

Date.	Temperature.	Pressure.	Average absolute humidity.	Interval of time from contact with drying agent.	$1/k_{760}$	$k_{760} \times 10^6$	Mean $k_{760} \times 10^6$	Number of large ions per cm³.
1908	° C.		gm/m³	mins.				
March 26	24·0	756		1	2790 –	358 –		9470
„ 27	23·0	755		„	2700 –	370 –		3320
„ 30	22·5	757	8·0	„	2750 –	364 –	363	5290
„ 31	23·0	755		„	2700 –	370 –		2670
April 1	„	759		„	2820 –	355 –		7870
„ 30	18·9	769		3	2420 –	413 –		18330
„ 30	„	768		„	2580 –	388 –		7050
May 1	19·0	766	5·5	„	2210 –	452 –	419	11750
„ 5	„	757		„	2340 –	427 –		10180
„ 5	„	„		„	2400 –	417 –		8930
April 28	18·2	766	5·4	7	1810 –	552 –	555	7680
„ 28	„	„		„	1810 –	552 –		„
May 11	18·1	763		„	1830 –	546 –		11880
„ 11	„	„		„	1820 –	549 –		10540
„ 13	18·0	758		13	1790 –	559 –		5950
„ 14	18·4	756		„	1750 –	571 –		4800
„ 15	17·5	767		„	1780 +	562 +		3260
1909								
April 2	22·0	758		„	1840 +	543 +		5110
„ 5	21·0	766		„	1790 +	559 +		1770
1908								
Oct. 22	16·7	766		„	1270 +	787 +		6930
„ 28	19·1	765	0·6	„	1220 –	820 –	798	6250
„ 28	„	„		„	1270 –	787 –		„
1909								
Jan. 21	[26 0	752		„	2600 +	385 +]		3320
„ 25	25·5	764		„	3190 +	313 +		6240
Feb. 1	23·5	762		„	2910 +	344 +		1380
„ 3	23·0	756	18·4	„	3190 +	313 +	317	3190
„ 4	22·3	762		„	3190 –	313 –		1600
„ 5	21·6	768		„	3330 –	300 –		2440

where some interlocking of the measures was possible. For the measurements with an average humidity of 18·4 gms. per cubic metre, air was used from a water sealed gasometer,

and just before entering the testing pipe it passed, without bubbling, over water contained in a covered shallow tray.

Owing to the extreme variability of the natural ionisation, it does not seem possible, in such an investigation as that described, to obtain measures sufficiently accordant for the purpose of a discussion of small corrections, but following a suggestion made by Mr. Sutherland, all the observations have been reduced to a pressure of 760 mm., on the assumption that the mobility varies inversely as the density of the air. The results do not show any indication of a difference between the mobilities of the positive and negative ions.

Included in the table are the values of the number of large ions per cubic centimetre at the time of each observation, calculated from the value of the ionic charge, $4{\cdot}65 \times 10^{-10}$ electrostatic units, lately determined by Professor Rutherford and Dr. Geiger.[1] The discussion of the results is reserved for a following paper.

[1] Rutherford and Geiger, Proc Roy. Soc., A. 81, p. 162, 1908

NOTE ON THE DETERMINATION OF THE FREE ACID IN SUPERPHOSPHATES.

By F. B. GUTHRIE, F.I.C., F.C.S., and A. A. RAMSAY.

[*Read before the Royal Society of N. S. Wales, June 2, 1909.*]

SUPERPHOSPHATE in contact with grain is frequently found to have an injurious effect upon its germinating power. This is particularly the case when the grain is moist, and McAlpine[1] has shown that the germinating power of wheat is very considerably affected by bringing grain which has been previously moistened with formalin or bluestone into contact with superphosphate before sowing. This action is undoubtedly due to the presence of free acid in the superphosphate, and the object of the present experiments is to test the methods by which the free phosphoric acid can be determined by titration with soda, using different indicators and by Thomson's and Glücksmann's methods.[2]

Summary of Results.

	Per cent. H_3PO_4
Gravimetrically	94·84
Titration with NaOH using different indicators—	
Methyl Orange	83·14
Phenolphthalein...	88·18
Litmus	92·24
Cochineal...	82·87
Thomson's method	92·32
Glücksmann's method using ·5 gm, in 250 cc. ...	90·18
,, using ·5 gm. in 500 cc. ...	89·32

[1] Agricultural Gazette of N.S. Wales, May 1906, p. 428.

[2] See Sutton, "Volumetric Analysis," 9th edition, pp. 113, 114.

A method published by Gerhardt[1] was also investigated, but gave very unsatisfactory results. The method depends upon the formation of superphosphate when calcium carbonate is neutralized by phosphoric acid, according to the equation $2\,H_3PO_4 + CaCO_3 = H_2O + CaH_4\,(PO_4)_2 + CO_2$ This reaction is not, however in accordance with observed facts. The method will be made the subject of further investigation before a decided opinion is expressed upon it.

Herzfelder[2] finds that none of the processes in use are trustworthy and suggests a new one based on the facts that free phosphoric acid is soluble in ether and that phosphates are not, and that monobasic phosphates are neutral to methyl orange and dibasic phosphates alkaline.

It was thought that it would be interesting to study the behaviour of different indicators towards free phosphoric acid and phosphates. Phosphoric acid was prepared by burning phosphorus in an excess of oxygen, dissolving the pentoxide formed in water, evaporating and drying in a desiccator under diminished pressure.

A. 10 grammes of this phosphoric acid was dissolved in 1000 cc. water and 20 cc. (containing ·2 grms. acid) titrated with decinormal soda, using various indicators.

B. 2 grammes of the phosphoric acid prepared as above described was treated in the cold with successive portions of ether (free from water and alcohol) a small amount of residue was left behind. The ethereal solution was evaporated off, water being added until the ether was expelled and an aqueous solution of phosphoric acid obtained. This was made up to 200 cc., and portions of 20 cc. (·2 grams. H_3PO_4) were titrated against N/10 NaOH, using different indicators.

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[1] Chem. Zeitung., 1905, Vol. XXIX, p. 178.

[2] Analyst, Vol. XXVIII, No. 333, p. 372.

C. 2 grammes phosphoric acid was exhausted with ether in a Soxhlet extractor for 10 hours. It dissolved completely. The ethereal solution was converted into an aqueous one as with B, and portion containing ·2 grammes H_3PO_4 were titrated against N/10 NaOH, using different indicators.

The results obtained were as follows:—

Indicator.	A H_3PO_4 dissolved in water.	B H_3PO_4 in ether (cold).	C H_3PO_4 extracted with ether.
Methyl orange	68·71	68·69	68·99
Phenolphthalein	68·57	61·42	68·72
Cochineal	68·41	70·02	70·09
Litmus	75·12	74·56	71·09
Congo Red	69·45	71·89	71·00
Lacmoid	70·25	72·16	72·82
Resorcin derivative ...	69·10	72·16	72·82
Turmeric	69·87	71·63	70·09
Sodium alizarin sulphonate	69·45	69·75	69·17
Gravimetrically		69·52	

With regard to the sharpness and delicacy of the end reactions the following notes are appended, from which it will be seen that both for the sharpness of the end reaction and the accuracy of the results the sodium salt of alizarin sulphonate is by far the most satisfactory indicator.

End points of titrating H_3PO_4 with NaOH.

1. Methyl orange—Fairly sharp.
2. Phenolphthalein—The point at which just a trace of pink appears is sharp, but after that point each drop up to 4 or 5 does not seem to deepen the colour so much as the 6th, 7th, and 8th drop does.
3. Cochineal—Fairly sharp, the change from red to purple.
4. Litmus—To first change, namely red to purple, sharp, but the purple continues a long time and takes a long time from purple to blue; unsatisfactory.

5. Congo red—Fairly sharp.
6. Lacmoid—Not so sharp on account of the purple transition.
7. Resorcin derivative—Not sharp.
8. Turmeric—Not good.
9. Sodium alizarin sulphonate—Very sharp.

Behaviour of indicators towards mono- and di-basic phosphates.

Pure mono- and di-basic phosphates of sodium and calcium were prepared according to methods given for the preparation of these salts in Roscoe and Schorlemmer, and in Watts' Dictionary of Chemistry. The following table shows the number of cc. N/10 NaHO or N/10 H_2SO_4, which were required to neutralize 0·2 grammes of these respective salts.

	Mono sodium phosphate NaH_2PO_4 ·2 grms.	Di sodium phosphate Na_2HPO_4 ·2 grms.	Mono calcium phosphate $CaH_4(PO_4)_2$ ·2 grms.	Di-calcium phosphate $Ca_2H_2(PO_4)_2$ ·2 grms.
Methyl orange ...	·648	**6·535**	·448	**8·747**
Phenolphthalein ...	13·851	**·402**	17·937	·498
Cochineal	·607	**6·495**	·349	**8·747**
Litmus	1·697	**6·535**	1·395	**1·548**
Congo red	·678	**6·636**	2·491	**2·916**
Lacmoid	·697	**6·535**	1·196	**7·943**
Resorcin derivative	·607	**6·736**	2·192	**11·965**
Turmeric	15·146	...	18·136	·498
Sodium alizarin sulphonate	·349	**4·323**	·149	**9·351**

The heavy black figures represent the number of cc. of decinormal acid, those in ordinary type of decinormal alkali required to neutralize ·2 grms of the respective salts.

The strength of the solutions operated on were 10 grammes in 1000 cc. water, 20 cc. being taken for titration. Since superphosphate of lime is stated to be soluble without decomposition only in dilute solutions, a solution containing 2·5 grammes per litre was employed in this case ($\frac{1}{1000}$ atomic solution).

[1] Watts' Dictionary of Chemistry, Vol. IV, p. 109.

These figures show that mono-basic posphates of sodium and calcium are not quite neutral to methyl orange, but slightly acid. They are more nearly neutral to the alizarin derivative. The di-bassic salt of sodium is alkaline to all indicators, but the di-basic calcium phosphate is acid towards phenolphthalein and turmeric. The sharpness of the end reaction of the different indicators used towards these salts is shown in the following table.

	NaH_2PO_4	Na_2HPO_4	Mono-calcium phosphate.	Di-calcium phosphate.
1. Methyl orange	fair, not very sharp	fair	not very sharp	fair
2. Phenolphthalein	fair	sharp	fair	fair
3. Cochineal	fair	not sharp, purple colour produced and difficult to tell end point	fair	fair
4. Litmus	not good, purple colour produced and transition to blue is long	not sharp	not at all sharp	not sharp
5. Congo red	not sharp	very bad (dirty black colour produced before the blue)	not sharp	end reaction very bad
6. Lacmoid	not sharp	not sharp, (purple produced).	fairly sharp	not good
7. Resorcin derivative	not sharp	very bad	not sharp	not good
8. Turmeric	not sharp very bad	very peculiar (see below)	not at all sharp	not at all sharp
9. Sodium alizarin sulphonate	very sharp	very sharp	very sharp	not very sharp

The behaviour of turmeric with di-sodium phosphate is most peculiar. If 20 cc of the original solution (10 grms. per 1000) is taken, a drop or two of tumeric gives a brown coloration (indicating alkalinity) and about ·3 cc. of N/10 H_2SO_4 are required to neutralize it. If, however, the 20 cc.

be diluted with water, turmeric gives an acid reaction and about ·5 cc. N/10 NaOH are required to neutralize it. This may be due to ionization of the solution on dilution, but it is strange that other indicators do not show the same phenomenon.

It will be seen from the above that none of the methods recommended are quite satisfactory, and that extraction with ether, subsequently converting into an aqueous solution and titration with methyl orange (Herzfelder's method) though the best of those recommended gives only approximate results in the case of phosphoric acid, while the acid phosphates are not neutral towards it.

By far the sharpest indicator is the sodium salt of alizarin sulphonate which is prepared by acting upon alizarin with fuming sulphuric acid, and converting the alizarin sulphonic acid into a sodium salt by neutralizing with sodium carbonate. This indicator gives extremely sharp end-reactions with free phosphoric acid, either in watery or ethereal solution, and is almost neutral towards the acid sodium and calcium salts.

A modification of Herzfelder's method, in which ether is used to dissolve out the free phosphoric acid, the ethereal solution converted into an aqueous one, and the free acid titrated with standard alkali using sodium alizarin sulphonate as an indicator, will probably prove to be the best method for determining the amount of free phosphoric acid in superphosphates. Further experiments will, however, have to be conducted before this method can be safely recommended.

DESCRIPTIONS OF NEW HAEMOPROTOZOA FROM BIRDS IN NEW SOUTH WALES, WITH A NOTE ON THE RESEMBLANCE BETWEEN THE SPERMATOZOA OF CERTAIN HONEYEATERS (Fam. MELIPHAGIDÆ) AND SPIROCHAETE-TRYPANOSOMES.

By J. BURTON CLELAND, M.D., Ch.M. (Syd.), Principal Assistant Microbiologist, and T. HARVEY JOHNSTON, M.A., B.Sc. (Syd.), Assistant Microbiologist.

(From the Bureau of Microbiology, Sydney).

[With Diagrams I, II, and Plates I, II.]

[*Read before the Royal Society of N. S. Wales, July 7, 1909.*]

FOR some years, one of us (J. B. Cleland) in Western Australia, has examined, as opportunity offered, blood films from various native birds with the object of detecting parasitic protozoa, but with uniformly negative results. Recently we have made a thorough examination of the blood and tissues of various wild birds in the neighbourhood of Sydney, with the result that no less than six apparently new species of protozoa have been discovered by us, four of which form the subject of this paper. The importance of studying and describing these forms has appealed to us, as thereby light may be thrown on the life-histories of some of the protozoal parasites so destructive to various animals of economic importance. With this view and with the object of helping other observers in Australia to correlate their results, we have compiled this paper descriptive of some of the types that we have so far encountered.

It is with considerable hesitation that we have ascribed specific names to such of these species as manifest slight,

if indeed actually distinguishable, differences in the part of the life cycle examined by us, from other known forms. We have decided, however, to do so tentatively and for the following reasons:—

1. In mammals, the parasitic haematozoa seem as species to be absolutely confined to one species of host only, or if found in more than one, the species so affected are closely allied members of the same genus if not varieties of each other (*e.g.* the malarial plasmodia of various races of man, the leucocytozoon of *Mus rattus* and *decumanus*). We have supposed that the same is likely to hold good, to some extent at least, amongst the *Aves* and so, in the present state of knowledge, pending actual experimental inoculations into species-hosts of other genera, we have decided to class as distinct the parasites occurring in hosts not belonging to the same or a very closely allied genus.

2. It will coordinate the results of a complete examination of the avian kingdom for protozoal parasites, if a specific name and a full description is appended to the parasite of any particular species, by which the parasite can be, as it were, labelled and handled. For this reason, as is now the custom, we have applied, as the specific name, the name of the genus to which the host belonged.

The Halteridia which we have found in *Ptilotis chrysops* and *Philemon corniculatus* call for little comment. An interesting form, in which multiple infections of single host-cells occurred with much frequency, was seen in that of *Meliornis novæ-hollandiæ.* In the Halteridium of *Geocichla lunulata* numerous free or nearly free gametocytes were seen and also interesting forms which suggested to us the formation of two separate gametocytes, one at each end, from single halter forms in some cases.

To the end of the paper, we have appended a short note on the superficial resemblances shewn between the sper-

matozoa of two species of *Meliornis* and Spirochaete-trypanosomes. Should a male bird be shot in the breeding season and the abdominal cavity injured, it is possible (as occurred with us) that some of these spermatozoa might gain entrance into the blood-films and lead to puzzling results.

We are indebted to one of our assistants at the Bureau, Mr. G. Grant, for the microphotographs.

HALTERIDIUM PTILOTIS (*sp. nov.*), from the blood of *Ptilotis chrysops*, (Fam. Meliphagidæ).

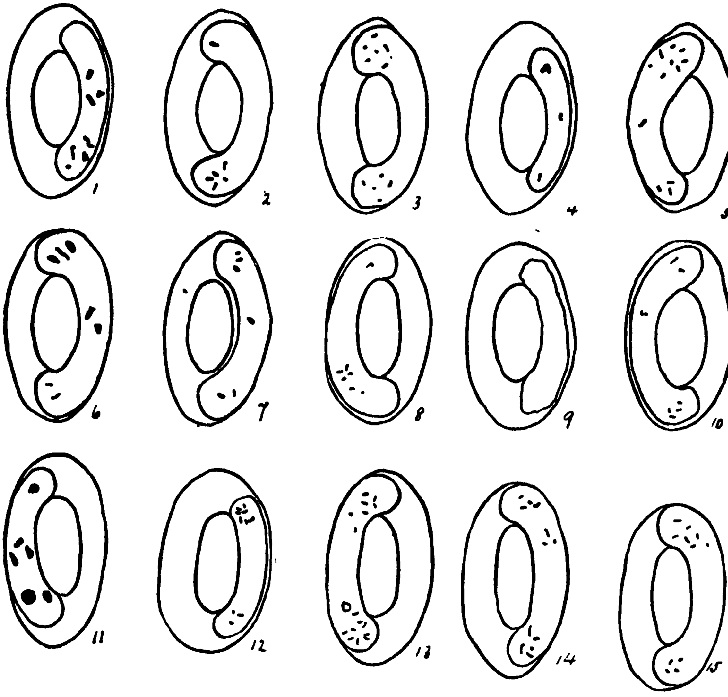
(Diagram I, figs. 1 – 15.)

In the blood of a specimen of *Ptilotis chrysops*, shot at Milson Island, Hawkesbury River, in April, 1909, a few Halteridia were found. Only the larger forms of the parasite were met with, from a size extending half-way between the nucleus and the end of the red cell to specimens occupying the side and all this space and quite embracing the nucleus save on its opposite lateral aspect. Some of these latter must have occupied fully three-fourths of the available space, and in one or two examples there was some suggestion of displacement to a slight degree of the nucleus.

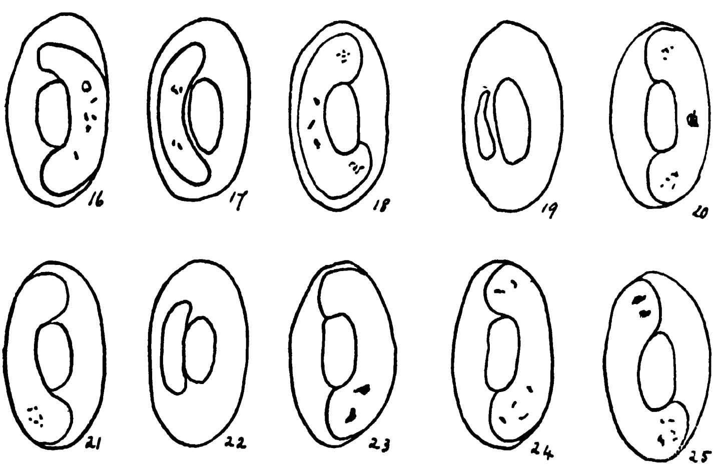
The following is a description of twenty consecutive parasites arranged afterwards according to the appearances presented :—

1. Protoplasm quite clear. Melanin aggregated as coarse masses, 6 at one end, 8 at the other.
2. Protoplasm quite clear. Melanin aggregated as coarse masses, 4 at one end, 7 at the other.
3. Protoplasm very pale. Melanin as rods (9 and 7) at each end.
5. Protoplasm faint. Melanin as coarse masses (5 and 6) towards each end.

Diagram I.



Halteridium ptilotis



Halteridium philemon

6. Protoplasm faintly granular. Melanin as coarse masses (5 and 6) towards each end.
7. Protoplasm faintly granular. Melanin as coarse masses (4 and 8) towards each end, one in centre.
8. Protoplasm fairly well stained, granular. Melanin as 5 masses in the middle but towards one end: one mass at other end.
9. Protoplasm fairly well stained, granular. Melanin as 2 masses near one end, 1 in the middle, and 4 at the other end.
10. Protoplasm fairly well stained, granular. Melanin masses, 1 at one end, 2 opposite host nucleus.
11. Protoplasm fairly well stained, granular. Melanin masses, 4 at one end, 4 opposite host nucleus, 2 at other end.
12. Protoplasm fairly well stained, granular. Melanin masses, 3 at one end, 4 opposite host nucleus throughout its length.
13. Protoplasm fairly well stained, granular. Melanin masses 4 near one end, 1 in centre, 1 at other end, 2 between these last.
14. Protoplasm fairly well stained, granular. Melanin masses, 3 large at one end, 2 smaller at other, 2 large opposite host nucleus.
15. Protoplasm deepish stained, granular. Melanin masses 3 at one end, 3 opposite host nucleus.
16. Protoplasm deepish stained, granular. Melanin masses 3 irregular large at one end, 3 opposite nucleus.
17. Protoplasm deepish stained, granular. Melanin masses, 2 at one end, 2 wide apart at the other end, 3 small opposite nucleus.
18. Protoplasm deepish stained, granular. Melanin masses, several irregular at one end, 4 irregular passing towards other end.

19. Protoplasm deepish stained, granular. Melanin as spherical masses, 2 towards one end, 1 towards other, 3 opposite nucleus.
20. Smaller, very little, if any, pigment. Outline of parasite irregular. Evidently an immature form.

The clear and pale forms probably represent male gametocytes. In two of these, the pigment occurred as rods, in the others as masses. It was aggregated more or less definitely at one end. This arrangement of the pigment corresponds with that in the described microgametocytes.[1] The deepest stained ones may be, on the other hand, macrogametocytes. In these, there seems a decided tendency for the melanin masses to approach nearer to one end than the other, or to be greater towards one end. The intermediate stained ones, which show a similar arrangement of the melanin, are perhaps schizonts. It would appear, however, that all stages are met with as regards depth of staining between the quite clear and the most intensely stained and that overlapping as regards the arrangement of the melanin similarly occurs. The amount of pigment did not seem to vary between the extreme forms. The only difference noticed was that in two of the pale forms, it was rod shaped, while in the others angular.

In examining other examples of the parasites, vacuoles were seen in two instances, in faintly granular specimens, towards one end (*Diagram* I, fig. 13). In one, this end was that containing decidedly more pigment than the other. In occasional large forms, no pigment was discernible (*Diagram* I, fig. 9). The red cells measured 11·5 to 12 × 6μ. Some of the parasites 9 × 2μ, 10 × 2μ, 11 × 3μ, 12 × 2·5μ, and 13 × 2μ.

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[1] Minchin's Article 'Sporozoa' in Ray Lancaster's Treatise on Zoology, Part i, 2nd fasic, p. 268.

The type slide has been presented to the Australian Museum, Sydney, and co-types are being retained by the Bureau.

HALTERIDIUM PHILEMON, *sp. nov.*, a blood parasite of *Philemon corniculatus*, (Fam. Meliphagidæ).

(Diagram I, figs. 16 - 25,)

The bird containing these parasites was shot at the Experimental Station of the Bureau on Milson Island, Hawkesbury River, in April 1909. In the early stages, the parasites appeared as small elongated bodies lying in the cytoplasm of the red cell, usually more or less lateral to the nucleus, but not infrequently towards one end of the host cell and even beyond the host nucleus. Their outline was sometimes indistinct and irregular, in others definitely circumscribed and roundish or oval. Many had a clear centre with a distinctly blue-stained surrounding ring or with the ends more deeply stained than the body. In forms much less in length than the host nucleus, minute grains of melanin could be detected. In a young parasite about the size of the host nucleus, they occurred as a row of fine granules along the side of the parasite next to the nucleus.

As the parasites became larger they always assumed a position lateral to the host nucleus and extended beyond this and curled round its ends in such a way that, in the largest forms, the mesial sides of the ends were flush with the distal side of the nucleus, the parasite then occupying the whole of one side of the red cell and most of the space between the ends of the nucleus and the extremities of the red cell (*Diagram* I, figs. 23 and 25). In one case, quite two-thirds of the available space in the host cell were thus occupied (*Diagram* I, fig. 18), and it appeared as if the nucleus had been slightly pushed laterally, though this may have been a fault in fixation. In the large forms, the melanin

appeared, 1, as scattered irregular granules throughout the parasite, 2, as two or three irregular masses of large granules, or as rods in various positions in the cytoplasm, 3, as a combination of (1) and (2), and 4. as distinct accumulations at the two ends, which might be equal in amount or one be decidedly greater than the other.

The protoplasm stained sometimes very faintly, sometimes a little more deeply, and then had a granular appearance. In some specimens irregular colourless spaces, often of considerable size, could be seen, perhaps of a vacuolar nature. The following is a description of twenty consecutive full sized parasites, arranged according to the appearances presented:—

1. Very faintly stained. Melanin as irregular masses at each end with a small one in the centre.
2. Very faintly stained. Melanin as irregular masses at each end.
3. Very faintly stained. Melanin as irregular mass and 3 rods at one end.
4. Faintly stained. Melanin as 3 rods at or near one end, as one rod opposite the same end of the host nucleus, and as 2 rods at the other end of the parasite.
5. Faintly stained. Melanin as 5 bunched rods at one end, as 4 scattered rods at other.
6. Fairly but faintly stained, granular. Melanin as 7 small masses opposite and a little beyond nucleus.
7. Fairly but faintly stained, granular. Melanin as 1 mass opposite centre with a rod shaped one external to it, as another rod shaped mass opposite end of host nucleus and as 2 small rods towards same end of parasite.
8. Fairly but faintly stained, granular. Melanin as a mass at one end, a smaller one towards the other, and a minute one in the centre.

9. Fairly stained, granular. Melanin as large mass in middle, smaller ones at each end.
10. Fairly stained, granular. Melanin as small masses in a row opposite and just beyond the host nucleus and on the side of the parasite next to the nucleus.
11. Fairly stained, granular. Melanin as 2 small masses at one end, 1 opposite the host nucleus, and 4 towards the other end.
12. Fairly stained, granular. Melanin as 5 small masses opposite nucleus, 2 towards one end of parasite and 1 towards other.
13. Better stained, granular. Melanin as 4 small masses opposite one half of host nucleus.
14. Better stained, granular. Melanin as mass beyond host nucleus at one end, a smaller mass at other end and 1 in centre.
15. Better stained, granular. Melanin as small granule opposite one end of host nucleus, and as a long rod shaped and 3 rounded masses towards other end of parasite.
16. Better stained, granular. Melanin as 2 large masses towards one end.
17. Better stained, granular. Melanin as 2 masses opposite host nucleus and a large and a small one at one end of parasite.
18. Better stained, granular. Melanin as 2 large masses in centre.
19. Better stained, granular. Melanin as irregular masses opposite host nucleus and a small one at one end of host nucleus.
20. Better stained, granular. Melanin as 2 large masses opposite host nucleus, as a smaller mass towards one end of parasite and a still smaller one towards the other.

In the above list, Nos. 1, 2 and 3, with very faintly stained protoplasm and the melanin collected at the ends of the parasites are undoubtedly early male gametocytes. Nos. 4 and 5 are also probably males. Some at least of the deepest stained examples (*e.g.* figs. 13 to 20), must be considered as female gametocytes. The melanin here, though sometimes near one or both ends of the parasite, occupied very frequently more central positions and was perhaps greater in amount than in the males. Of the rest, some may be either male or female, but the majority are probably trophozoites. The position of the pigment varied. It must be noted, however, that all stages could be found between the most typical macrogametocytes and microgametocytes. Similarly rod shaped masses of melanin were found in all forms. In no instance, with the stain employed (Giemsa's), could the nucleus of the parasite be detected, and no forms were seen in stages of schizogony. The measurements of the red cells of this bird were $11{\cdot}5 \times 6\mu$. Some of the smaller parasites noticed were $5 \times 1\mu$, others still smaller and more spherical. Medium sized parasites, in which the ends had barely begun to embrace the nucleus, measured $12 \times 2\mu$, and large curved forms $14 \times 3\mu$, counting in the measurement the curve of the parasite.

We propose the name of *H. philemon* (sp. nov.) for this parasite, adopting for the specific name the generic name of the host. This parasite, in the largest forms seen, appears to occupy a relatively greater amount of the cytoplasm of the host cell than do the largest forms seen in *H. ptilotis*. Beyond this, little difference could be detected, and the identity or otherwise of the two must await the investigation of other stages in their life-histories.

The type specimen has been deposited in the Australian Museum Sydney, and the co-type is being retained by the Bureau of Microbiology.

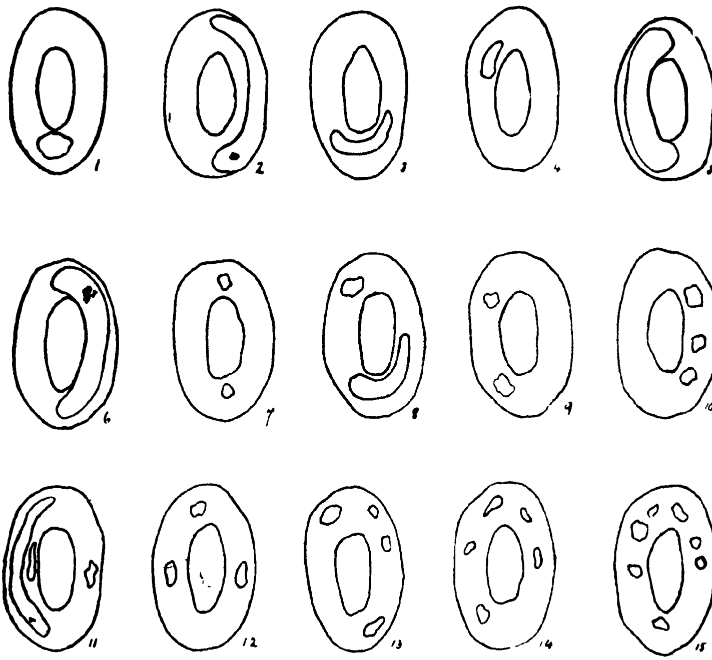
HALTERIDIUM GEOCICHLAE, *sp. nov.*, from the ground-thrush *Geocichla lunulata.*

(Diagram II, figs. 16 – 26.)

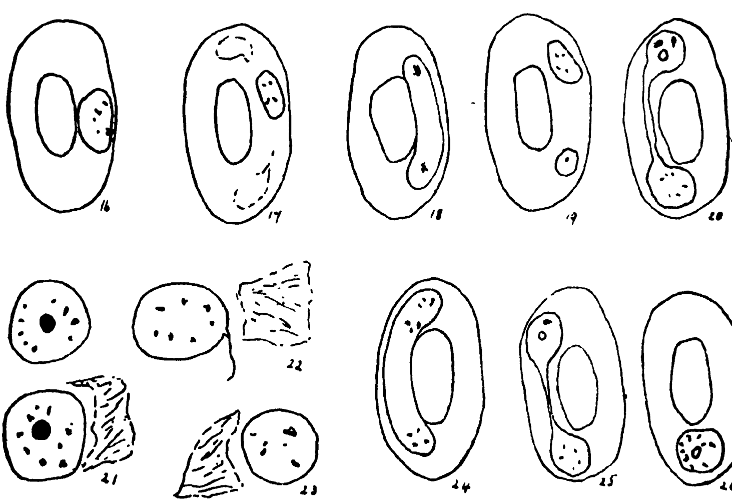
In the blood films made from the ground thrush *Geocichla lunulata* shot at the Bulli Pass, N.S. Wales, in April 1909, numerous specimens of a Halteridium were met with. A number of these were found *in situ* embracing the nucleus, but quite as many appeared as rounded gametocytes in or near broken red cells. Since nearly every red cell which had been ruptured during the making of the blood films shewed in its fragmented nucleus or near to it, one or two of these gametocytes, it may be fairly assumed that such cells, owing to the presence of the parasite, had been more fragile than their unaffected fellows and had burst from tension in the process of making the blood film. The earliest stages met with were about three-quarters grown halter forms. Typical full sized halter forms presented two main types, a very pale form and a fairly stained granular one, representing male and female gametocytes. The following is a description of twelve consecutive full sized forms, arranged according to their appearances:—

1. Clear protoplasm. Melanin as 3 grains towards one end, 2 at other, and mass of grains near centre.
2. Nearly clear protoplasm. Melanin as 4 grains towards one end, 4 grains towards other end and a mass of grains opposite this end of nucleus.
3. Nearly clear protoplasm. Melanin as 7 large grains at one end, 3 at other.
4. Staining faintly. Melanin as group of grains at one end, 1 grain and vacuole at other.
5. Fairly stained, granular. Melanin as irregular reticulated masses at or towards each end.
6. Fairly stained, granular. Melanin as irregular mass at one end, 2 grains towards other end, 1 grain in centre.

Diagram II.



Halteridium melcornis



Halteridium geocichlae

7. Fairly stained, granular. Melanin as mass of grains at one end, 2 grains towards other end, 3 grains in centre.
8. Fairly stained, granular. Melanin as mass of grains at one end, mass and isolated grain at other, 1 grain and vacuole near centre.
9. Fairly stained, granular. Melanin as mass of grains at one end, and several grains and vacuole near it, 7 grains towards other end.
10. Fairly stained, granular. Melanin as 4 large grains and vacuole at one end, 4 large grains at other.
11. Fairly stained, granular. Melanin as mass or grains at one end, 1 grain in centre.
12. Fairly stained, granular. Melanin as 3 small masses at one end of nucleus of host cell, 3 grains towards other end of parasite.

The following interesting forms were met with at various times:—

13. Very pale. Melanin as mass of granules at one end, 2 granules at other.
14. Very pale. Host nucleus shoved to one side. Melanin as mass of granules at one end, 5 large granules beyond centre towards other end.
15. Fairly stained, granular. Melanin as large mass of pigment towards one end, no pigment but vacuole towards other.
16. Fairly stained, granular. Melanin as large mass with vacuole at one end, 1 grain opposite centre, 1 grain just beyond other end of host nucleus.
17. Fairly stained, granular, the two ends of the parasite connected by a band narrower than normal. Melanin as a large mass at one end, a small mass and vacuole at other.

In the above list, Nos. 1, 2, 3, 13, 14 and perhaps 4 are evidently male gametocytes in an early stage. Vacuoles

were not seen in any of these forms. The pigment was usually at or near the ends of the parasite. The other forms, with protoplasm much more definitely stained, are probably mostly female gametocytes, though some are perhaps schizonts. The pigment was perhaps more massive in these. Frequently a definite vacuole was present at one end.

A number of gametocytes, both male and female, in the stage following on this were noticed. In both forms the parasite, after reaching the above stage seemed to contract towards its centre, becoming firstly a flattened oval and finally spherical in a position lateral to the host nucleus. Having reached this last form, it appeared as a distinct bulging in a distorted red corpuscle, which, from the large number of ruptured blood cells encountered, would then appear to be more fragile than normal, probably from the tenseness of the bulging. Forms quite free from the host cell were not infrequent. The two sexual types could be quite easily followed in this evolution. In the male type, in the elongated oval form, was disclosed in favourable specimens an elongated pinkish nucleus. In the mature male gametocyte, the nucleus was frequently observed as an irregularly round body in a protoplasm apparently quite unstained. The pigment appeared as scattered fine granules sometimes as a circle round the nucleus. In one example, the male gametocyte was very much larger than others seen, its diameter being equal to that of the long diameter of a red cell; its nucleus was divided into three irregular masses and one rod shaped mass, separated by considerable intervals; its pigment was scattered as fine granules. In another of normal size, several delicate flagella-like bodies were noticed attached to its circumference (? possibly microgametes).

The mature female forms were all of one size, were well stained, granular; a vacuole was often seen; and the pig-

ment often occurred as small masses; we could not detect the nucleus in any. These were the typical forms of the parasite met with. A series of very puzzling ones was, however, encountered, suggesting possibly another phase in the life-history of the parasite. These consisted in all intermediate stages between the normal halter forms and individuals in which apparently separate rounded bodies occupied respective ends of the host cell.

Definite intermediate stages in the protoplasmic bridge between the two ends were seen (figs. 20, 25) in some the width of this bridge being a little less than normal, in others half the normal, in others a strand seen with difficulty. The parasites presenting these phases were well stained: there were no instances of its occurring in very pale (male) forms. The rounded bodies were usually well stained and granular and a vacuole was sometimes present in one. What is the nature of this process? Does it mean that in some examples of the parasite, the young female gametocyte can divide into two in the host cell? The bodies we saw thus formed resembled the free rounded female gametocytes and no evidence of schizony was noticed. On the other hand, we have apparently traced all the intermediate stages in the ordinary evolution of the female gametocyte to form one rounded mature body, and it is hardly to be expected that in some cases the halter form should produce one mature gametocyte, in others two in the same species and at the same time.

The corpuscles average $12 \times 7\mu$, the parasites varying in size from 4μ in diameter, in the case of expressed forms, to 11 or $12 \times 3\mu$ in the halter shaped organisms.

The type slide of *Halteridium geocichlae* has been presented to the Australian Museum, Sydney, co-types being retained by the Bureau.

HALTERIDIUM MELIORNIS, *sp. nov.*, **a haemosporidian from the Honey-eater** ***Meliornis novæ-hollandiæ.***

(Diagram II, figs. 1 - 15.)

In examining blood films made from a specimen of the honey-eater *Meliornis novæ-hollandiæ* (Fam. Meliphagidæ), shot at Sydney, in March 1909, numerous small parasites were found in the red cells. Probably one-fourth to one-sixth of the erythrocytes harboured these bodies, which were present sometimes singly (figs. 1 to 6), more often two in a cell (figs. 7, 8, 9), not infrequently three (figs. 10, 11, 12) or four (fig. 13), and rarely five (fig. 14) to even seven (fig. 15). They appeared in the earliest stages as small irregular faintly stained amoeboid bodies with clearer centres, situated in the protoplasm of the erythrocyte, usually lateral to one or other end of the nucleus (figs. 1, 4). When two were present, these might be situated diagonally opposite each other in the above situation (figs. 7, 8): when more than two, at the ends or sides of the red cells in various situations. As the parasite increased in size it tended to grow laterally along the side of the nucleus but without in the least displacing the latter (figs. 3, 4, 8). Halteridium-like forms were met with, though not in abundance, in which the two ends of the parasite projected beyond and curled slightly round the nucleus (fig. 5). These, however, differed from ordinary adult Halteridia in not having so definite an outline but instead the irregular illdefined, amoeboid-like margin (fig. 11) so common in plasmodium. Examples were also met with in which the parasite occupied one end of the red cell and part only of the side, ceasing opposite the beginning of the fourth quarter of the nucleus. The pigment in the parasite was always small in amount, consisting in the large halter-like forms of a few melanin granules usually aggregated not far from one end (fig. 2, 6), though in one case they were closer

to the centre. In half grown forms, a small melanin speck could in some cases be detected. In the young forms, no pigment was noticed.

An interesting feature was that, though in some of the cells containing general parasites, all were of about the same size, in others one or more were distinctly larger. A further stage of this was seen, when in one red cell a large halteridium form was met with, with a quite small, somewhat longitudinally flattened early form between it and the nucleus, and on the other side of the nucleus a small irregularly rounded amoeboid form (fig. 11). This red corpuscle was not distorted or enlarged, the only doubtful pressure effect noticeable being the narrowing of the form lying between the large parasite and the nucleus. Had the nucleus been displaced at all, this would have been manifested in the parasite on its further side. It is hard to say what would happen if all the forms in the multiple infected cells were of the same age and attempted to mature at once.

When first examining this species, the irregular amoeboid-like outline of the early forms and their abundance and the multiple injections of single host cells suggested that we were dealing with a species of Plasmodium. This was supported by the frequency with which the young parasite occupied other positions than one directly lateral to the host nucleus. On further search, however, halter-like forms were found, though these were not so large, and had not the definite sharp outline of ordinary adult Halteridia. That we are justified, however, in considering this parasite as a Halteridium, is evidenced, we believe, in the fact that forms like those presented in this case were found by us in other definite Halteridia. In our *H. philemon*, for instance, early forms of the parasite were seen occasionally with outlines like those of *H. meliornis*, and some of these

occupied situations more or less at one end of the host cell, and in *H. ptilotis* a single three-quarters grown parasite was noticed with an irregular outline as in the largest forms seen in the species *Meliornis.*

The size of the red corpuscles of *Meliornis novæ-hollandiæ* were $10{\cdot}5 \times 6\mu$, of its nucleus $6 \times 2\mu$. The size of the smaller forms of the parasite varied from $1 \times 1\mu$ to $6 \times 1{\cdot}5\mu$. Others were found $2{\cdot}5 \times 2{\cdot}5\mu$, $5 \times 1{\cdot}5\mu$, $8 \times 2\mu$, $11 \times 1{\cdot}5\mu$. The largest halter-like forms were $12 \times 2\mu$, $13 \times 2\mu$ and $14 \times 2\mu$.

We have given this new species of *Halteridium* the specific name of *meliornis*, this being the generic name of its host. The type specimen has been deposited in the Australian Museum, Sydney, and the co-type is being retained by the Bureau of Microbiology.

The Spermatozoa of the Honeyeaters *Meliornis novæ-hollandiæ* and *M. sericea*, (Fam. Meliphagidæ), and their resemblance to Spirochaete-Trypanosomes.

Plates I and II.

Amongst the few Australian birds producing autumnal as well as vernal broods, *Meliornis novæ-hollandiæ* and *M. sericea* are conspicuous. Male birds shot in March and April have large testes reaching the size of small peas. Whilst recently obtaining specimens of these birds for the purpose of examining their blood and organs for parasites, a curious coincidence occurred to us. A specimen of the former species was shot early one morning, being wounded in the abdomen ; dissected three hours later, blood smears were made from a large clot in the abdominal cavity. Stained by Giemsa, there were at once noticeable numerous flagellate bodies of two types scattered between the red cells. The long and narrower type often showed regular spiral curves at once suggestive of a spirochaete such as

that of spirillosis in fowls, while the shorter and broader form approximated more to a trypanosome. It was naturally at first supposed that here was a blood parasite resembling Schaudinn's famous *Trypanosoma noctuae*, perhaps appearing as does the trpanosome-form of that organism, only in the abdominal blood during the night hours (or daylight in this case)!

On further investigating the subject, however, and in eliminating all possible sources of error, we turned to an examination of the testes, and discovered in these organs of this species and of *M. sericca* abundant identical bodies, often in vast masses. It would appear that the injury of the shot wound or later manipulations in examining the bird had wounded probably the spermatic duct and liberated numerous spermatozoa which had become incorporated in the blood clot. It seems to us, therefore, important to record this possible source of error in the examination for haematozoa, of the blood of male birds during the breeding season. Some of the photographs will show how striking is the resemblance of these scattered spermatozoa embedded amidst the red cells, to flagellate parasites.

The Spermatozoa.—These bodies, as demonstrated by Giemsa's stain in films, showed considerable variations in size, from extreme tenuity and considerable length to forms which were truncated, band-like and short.

1. The long moderately thin forms—these usually showed more or less regular spiral windings, becoming more open towards the tail. They showed a very delicate pointed faintly blue-stained end, succeeded by a deeply stained purple part which gradually narrowed to be continued into the flagellum. At or near the junction of the faint blue end and this darker portion, could in favourable specimens, be detected a deeper stained purplish-crimson dot, the centrosome. Occasionally from this, the axial filament

seemed distinctly traceable, as it took spiral windings round a delicate blue protoplasmic envelope. In some cases, the anterior quarter of the deeper stained axial filament was thicker than the remaining three-fourths, and this part perhaps represented the 'middle' piece of the spermatozoon. Sometimes a delicate blue protoplasmic envelope could be seen surrounding this part; for the middle two-fourths, however, this envelope was often very noticeable and was always at one side, the concave, of the axial filament, as though this wound round the outside of it, much as the flagellum of a trypanosome does the body of that organism. Usually this protoplasmic envelope ceased to be evident for the last fourth of the flagellum, but several instances were seen in which either the axial filament ended in extreme tenuity some considerable distance from the end, which appeared as a delicate faint blue spiral, or had been torn from this protoplasmic bed and projected as a naked end while its normal situation was indicated by a similar delicate spiral. The nucleus could not be definitely discerned.

2. The broad, truncated, band-like forms—These showed a similar pointed, delicate, blue end, which was succeeded by a rather broad band-like reddish structure, narrowing somewhat posteriorly but not ending in a definite axial filament. A centrosome was sometimes discernible near the junction of the pointed end and deep stained portions. No definite nucleus was visible, and no definite protoplasmic envelope. Numerous forms were seen intermediate between these two types.

Sections of the testes, embedded in paraffin and stained by iron-haematoxylin and eosin, showed vast numbers of the spermatozoa *in situ*, grouped in masses. The spiral windings were conspicuous and all parallel. Nearly all were of the thin type but scattered, broader ones could

easily be found amongst them, probably representing immature and differentiating spermatozoa.

Measurements.—The long forms varied in length from 25·5 to about 20μ, their breadth being only ·5μ. The short forms varied from 18 to 13μ in length, and from 1·3 to ·5μ in breadth. The usual length was about 22μ. The differences in length are mainly due to differences in the number and amplitude of the undulations which varied from three to seven: five being most common. The long sperms were almost straight.

Resemblances to Spirochaete-trypanosomes.—In some ways these were striking. For instance, the delicate pointed end succeeded by a centrosome-like body were very similar to the posterior end of a trypanosome with its 'centrosome.' Then from this body, could be definitely traced in some cases, the origin of the axial filament which traversed the body apparently on the edge of a surrounding delicate protoplasmic coil, an appearance highly suggestive of the flagellum of the trypanosome arising from its centrosome and following the undulating membrane. In fact, practically the only point of difference between these spermatozoa as represented in Giemsa stained films and very delicate trypanosome bodies lay in the absence of any sharply defined nucleus in the former.

REFERENCES TO DIAGRAMS I, II, AND PLATES I, II.

DIAGRAM I—Figs. 1 – 15, *Halteridium ptilotis;* various specimens met with, indicating relative sizes of parasites and distribution of pigment.

Fig. 9, no pigment discernible.

Fig. 11, very coarse pigment

Fig. 13, vacuole at one end.

Figs. 16 – 25, *Halteridium philemon.*

Fig. 16 showing vacuole.

Fig. 18, very large form.

Figs. 19, 22, young forms.

DIAGRAM II Figs 1 – 15, *Halteridium meliornis.*

Figs. 1 – 6, showing single infection with parasite in various positions and stages of development.

Figs. 2, 6, pigmental forms.

Figs. 7, 8, 9, showing double infection.

Figs. 10, 11, 12, showing triple infection.

Fig. 13, host cell with 4 halteridia.

Fig. 14, host cell with 5 halteridia.

Fig. 15, host cell with 7 halteridia.

Figs. 16 – 26, *Halteridium geocichlae.*

Fig. 17, host cell showing a thinning of its protoplasm in two places, suggesting either an earlier infection, or else the withdrawal of the parasite from the extremities to form the rounded body seen in the figure.

Fig. 18, a nucleated form.

Fig. 19, double infection.

Figs. 20, 25, halteridia dividing? Both parasites are vacuolated.

Fig. 21, nucleated male gametocytes, with ruptured nucleus of host cell adjacent to one.

Fig. 22, gametocyte with flagella?

Fig. 23, female gametocyte (host nucleus lying adjacent).

PLATES I and II, Microphotographs of blood film from *Meliornis novæ-hollandiæ*, showing spermatozoa.

ON A NEW MELANIN-PRODUCING HAEMATOZOON FROM AN AUSTRALIAN TORTOISE.

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(From the Bureau of Microbiology, Sydney, N.S.W.)

[With Diagram I and Plate III.]

[*Read before the Royal Society of N. S. Wales, July 7, 1909.*]

DURING the examination of the blood of a specimen of the common Australian tortoise, *Chelodina longicollis*, captured near Sydney in April 1909, a number of pigmented parasites of the red cells was met with. The characteristics of these protozoa were a more or less regular spherical shape, occasionally in the younger stage with short amoeba-like projections, sometimes in the older stage with a kidney-shaped indentation, the site occupied being almost always the end of the corpuscle, very rarely the side; the non-displacement of the nucleus and the absence of any distortion of the host cell; the presence of masses of melanin pigment, and the presence of two (sometimes one, occasionally several or more) vacuoles.

On searching the literature at our disposal, we could only find two references to melanin producing haematozoa of reptiles, one, *Haemamoeba metchnikovi* described by Simond from a tortoise, *Trionyx indicus*,[1] and the other, *Haemocystidium Simondi* taken from a gecko, *Hemidactylus leschenaultii*, in Ceylon, and described by Castellani and Willey,[2] who made it the type of a new genus *Haemocystidium*.

[1] Simond, Ann. Inst. Past., 1901, p. 319.

[2] Spolia Zeylanica, Vol. II, pt. 6, August 1904, p. 84.

In the latter description the characteristics of this new genus are given as follows:—"In the earliest stage, the parasite appears as a small rather irregular or amoeboid body with a zone of pigment granules across the centre. At first the nucleus of the red corpuscle is only slightly displaced. With growth of the parasite the nucleus of the red cell becomes pushed to one end of the corpuscle. Sometimes the parasite is oval or somewhat irregular in contour. Sometimes it is round or lenticular. The elongated oval form nearly fills the corpuscle: only a narrow pink rim may be seen surrounding the blue body which moulds itself upon the nucleus of the blood cell. Judging from the analogy of other cases, it would seem that the spherical or discoidal form is the gametocyte or final stage of the trophozoite."

"Two very distinct types were met with, resembling each other in form but differing in their reactions to Leishman's stain. These no doubt represent sexual differences. In the male type the body is faintly granular and stained a delicate blue with numerous small pigment granules scattered round the periphery. In the other or female trophozoite the body is stained dark blue, the pigment granules though numerous appear to be slightly larger at times; and varying numbers of vacuoles of different sizes are always present. In the pale form vacuoles never occur."

"We propose to name the new genus with the characters which we have described *Haemocystidium*, on account of its rounded, turgid, more or less bladder-like shape and appearance."

Under this genus, they include Simond's *Haemamoeba metchnikovi*, while admitting that it differed in size, rarely exceeding half of the blood corpuscle, in the smaller number of the pigment granules and in not displacing the nucleus. They conclude by saying:—"It seems clear that *Haema-*

moeba metchnikovi belongs to our genus *Haemocystidium*, and it should henceforth be styled *Haemocystidium metchnikovi*, Simond."

As our species seems to agree generically with Simond's one, and is likewise from a tortoise, it follows that it should also be grouped under the genus *Haemocystidium*. But in the above somewhat vague definition of the genus, displacement of the nucleus assumes an important position, though in spite of the absence of this characteristic in Simond's parasite, this latter is included by Castellani and Willey in their genus. It must therefore follow that, if the genus is to hold good, displacement of the nucleus is not a necessary character. We accordingly suggest that the genus be amended as follows:—In early stages, the parasite is irregular or slightly amoeboid; in later stages, oval (? schizonts) or rounded, turgid, more or less bladder-like (? gametocytes): it produces melanin granules, vacuoles are frequently present, and there may or may not be displacement of the nucleus of the red cell; and the host is reptilian.

Little, therefore, remains to distinguish this genus from *Plasmodium*, though it can be at once distinguished from *Halteridium* by the absence or at least great rarity of halter-like forms and by displacing the nucleus in one species at least. As, however, it is probable that later researches into the complete life-history of these parasites will discover other and more marked differences between the forms included under *Haemocystidium*, all obtained from reptiles, and the genus *Plasmodium* as found in warm blooded animals (mammals and birds), we have considered it better to place our species under *Haemocystidium*, as thereby are kept together a small group of melanin producing haematozoa of reptiles which are doubtless species more closely interrelated between themselves than to somewhat similar

parasites found in warm blooded animals, even if not generically distinct from these. Summed up, in fact, on the material and descriptions before us, we are unable to draw any sharp distinction between the two genera *Plasmodium* and *Haemocystidium*, except that of the nature of the hosts. Minchin[1] seems to have experienced the same difficulty when classifying *Haemocystidium* as a synonym under *Plasmodium*.

Description of the Parasite.—Nearly all the forms met with were more or less rounded, and, we believe, represent the gametocyte stage. They correspond to the spherical male and female bodies described by Castellani and Willey, whose larger oval bodies on the other hand perhaps represent nearly mature schizonts. The only departure from the rounded shape that we encountered, save in immature forms, were occasional kidney-shaped parasites, and in one case an imperfect halteridium shape lying along the side of the corpuscle and slightly embracing the nucleus. With this exception, all the bodies occupied the end of the corpuscle, the shape of which was not distorted nor was the nucleus displaced in any instance. Immature forms were very few, and always half-grown, and showed a slightly irregular rounded contour with several short amoeba-like prolongations. Such prolongations were also seen in one nearly mature rounded form.

In some of the rounded bodies, the protoplasm was very faintly stained with very few granules: in others much more deeply coloured with scattered fine granules, sometimes with the circumference of the parasite clearly outlined by a deeper stained narrow zone. Intermediate stages between these two were met with, however, and vacuoles, one, usually two, occasionally several, were found in both very pale and deeply stained parasites, whilst

[1] Albutt and Rolleston's System. Med., Vol. II, part ii, p. 74.

in others they were absent. The melanin was sometimes in angular granules, sometimes in short rods; it was scattered irregularly as fine granules, confined to one half of the parasite, or grouped into little masses often towards the centre.

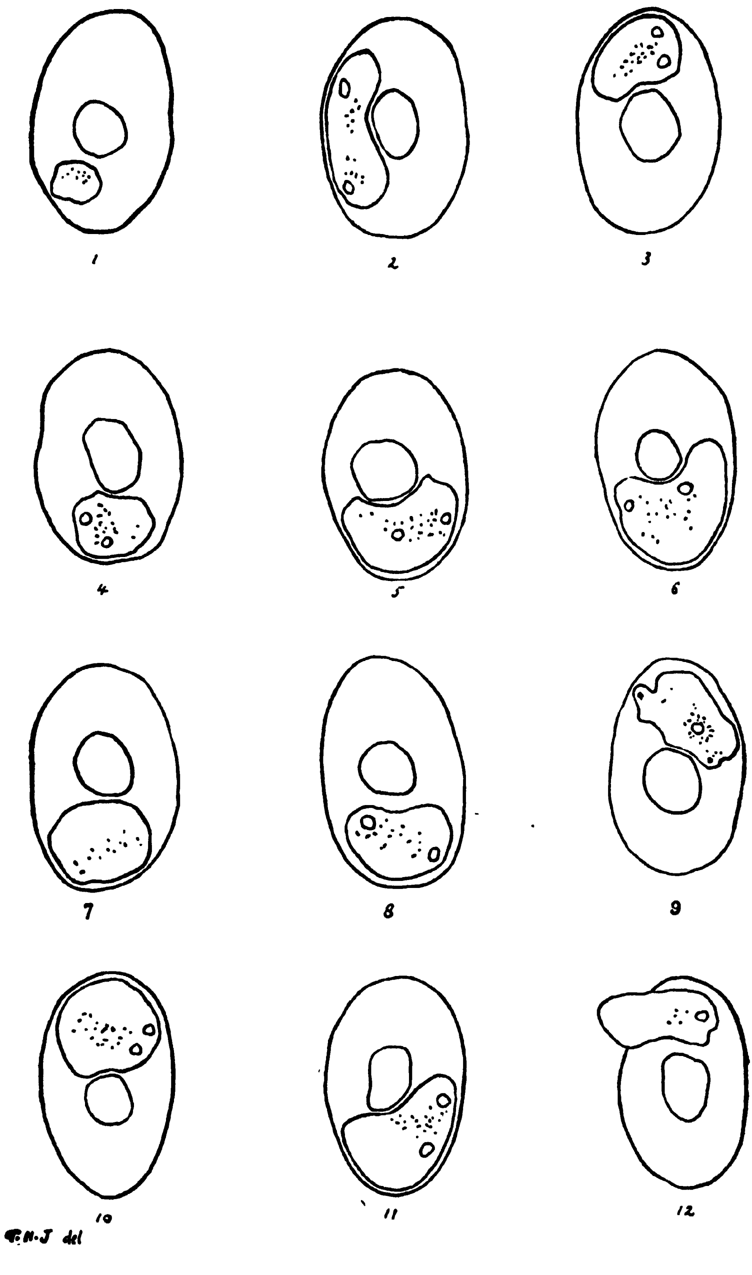
The erythrocytes of this tortoise were from 17 to 18·5 micra long by from 10 to 12 broad, the nuclei being about 5 by 3·5 micra. The parasites varied from 4 by 3 micra to 12 by 7. Their relative proportions and size are indicated in the figures. The average diameter of the large rounded forms was about 9 micra, whilst those possessing a reniform shape measured about 6 micra across the middle and reached a length of 12 micra. Only two specimens under 8 micra in their greatest length were seen. The vacuoles had a definite, rounded constant form, the diameter being about 1 micron. Their position was variable as the figures show.

We propose for this organism the name of *Haemocystidium* (*Plasmodium*) *chelodinae*. It differs from *H.* (*Plasmodium*) *metchnikovi* in the granules being more numerous and irregularly scattered, in the average size being a little larger, and in forms being present with large melanin granules and deep staining protoplasm, which agree with neither Simond's male nor female gametocytes.

The type slide has been presented to the Australian Museum and co-types have been retained by the Bureau.

Addendum.—In the Third Report of the Wellcome Research Laboratories of Khartoum, 1908 (1909), whose prospectus with abstracts has just reached us, we find that Dr. Wenyon has described three new species of melanin producing haematozoa from Soudanese reptiles, viz., *Plasmodium mabuiae* from a lizard, *Haemoproteus agamae* also from a lizard, and *Haemocystidium najae* from the Spitting Cobra (*Naja nigricollis*). We have not yet received the full report, and are therefore unable to compare these species with ours.

Diagram I.



EXPLANATION OF PLATE AND DIAGRAM.

PLATE III—*Haemocystidium chelodinae.* Microphotograph of portion of film, showing an erythrocyte (in the centre of the field) containing a parasite. The vacuoles and pigment are visible.

DIAGRAM I—*Haemocystidium chelodinae.*

Fig. 1, young parasite.
Fig. 2, elongated form.
Figs. 3, 4, 5, 6, 8, 10, 11, more usual forms; commonly somewhat amoeboid.
Fig. 7, non vacuolated form.
Fig. 9, distinctly amoeboid parasite.
Fig. 12, parasite protruding from injured host cell.

All the above were drawn with a camera lucida.

ON A NEW REPTILIAN CESTODE.

By T. HARVEY JOHNSTON, M.A., B.Sc., Assistant Government Microbiologist.

(From the Bureau of Microbiology, Sydney.)

[With Plate IV.]

[Communicated by C. HEDLEY.]

[*Read before the Royal Society of N. S. Wales, July 7, 1909.*]

A narrow, thread-like, rather delicate tapeworm occurs in the alimentary tract of the common Monitor, *Varanus varius*, Shaw. In a specimen of this lizard which I obtained near Bathurst, N.S. Wales, these parasites were present throughout almost the whole length of the intestine, being numerous in the duodenum. Their occurrence in the upper part of the rectum is worth noting, as this is not a usual place for cestodes. The length of the cestode is from 27 to 30 millimetres, probably more in fully mature specimens;

the thickness is only 0·04 mm., whilst the width gradually increases from 0·2 mm. in the neck region to 0·35 mm. in ripe segments. Thus the whole strobila is very thin and narrow. To the naked eye, it appears like a piece of fine white thread. Unless the intestine be carefully freed from its contents by gently washing under water, the parasite is likely to be overlooked. It adheres so firmly to the tissues that it is not an easy matter to remove it without injury.

The scolex is somewhat pyriform, the broader end being anterior. It lies buried in the mucosa which grows up round it; hence on removal of the worm, a pit-like depression remains. Its greatest width is from 0·32 to 0·4 mm., this being in the region of the suckers. The length is about 0·5 mm. The anterior end is prolonged into a short thick, conical rostellum, about 0·14 mm. in diameter at the base and 0·1 mm. in height. This structure is not retractile, and instead of bearing hooks, it possesses an apical muscle plug, an organ rarely met with in cestodes. In addition to the rostellum, the scolex bears four typical suckers, two dorsally and two ventrally. The cavity of each measures 0·08 mm. in diameter and 0·07 mm. in depth. The opening is circular, the whole organ being subspherical. The layer of muscle lining the cavity is about 16 micra thick, except at the base of the hollow where it reaches 20 micra. The musculature is thus comparatively powerful. The openings are directed anteriorly and very slightly laterally (fig. 1). The scolex becomes narrowed posteriorly to pass into the long neck, the width of which is 0·16 mm.

The strobila consists of very numerous proglottids that are indistinguishable to the naked eye, excepting at the end of the chain if mature segments be present, in which case the segmentation is just visible. There is no trace of overlapping of the anterior end of a segment by the

posterior border of the preceding one, nor is there any indentation marking their line of junction except in the sexually mature region of the chain. Even here the constrictions are slight. In egg bearing proglottids the separation is somewhat more marked. Segmentation is recognisable in cleared specimens, by the presence of delicate transverse septa which divide adjoining members of the chain (fig. 2). Young segments are very uniform in size, being 0·14 mm. long by 0·2 mm. broad, gradually increasing in width to 0·27 mm. The increase in size is so gradual that at a distance of twenty-five millimetres behind the scolex, they are only 0·48 mm. long by 0·34 mm. broad. There is a rather sudden increase in size when sexual maturity is reached; such segments being about a millimetre in length, the width scarcely altering *i.e.* 0·36 mm. (fig. 3). Egg-bearing proglottids may be as much as 2·5 mm. long and only 0·45 mm. broad. Hence there is no narrowing in ovigerous segments, nor is there any marked widening in those which are sexually mature. Ripe members of the strobila resemble elongated ellipses, their anterior and posterior margins being rounded off, and consequently segmentation is here quite distinctly shown. Although I examined a large number of specimens, ripe segments were quite uncommon. Some of the worms possessed abnormal proglottids of irregular shapes and sizes. They were apparently sterile and showed distinct segmentation.

The cuticle bears characteristic structures. Its surface is raised into tiny, backwardly directed spines, which are so numerous as to give the surface the appearance of having been finely stippled (fig. 1). One needs to examine the margin of the worm to see the spines in profile. They are so minute as to require the use of a high power of the microscope for their detection. It is on the scolex and

neck that these structures are best developed, whilst as we pass further back, they are less marked and are hardly distinguishable at all in mature proglottids. They are present on the cuticle lining the suckers. In transverse sections the cuticle is seen as a comparatively thick layer, immediately below which is a very well marked basement membrane separating it from the parenchyma (fig. 4).

The parenchyma is very loose in structure. The cortex is somewhat narrow and does not contain any calcareous corpuscles, these bodies being absent in this species. In the outer region of the cortex and immediately below the basement membrane is a very well defined layer of subcuticular cells, which are readily stained. They occupy nearly half the cortex.

The various parts of the musculature are not well developed. The dorso ventral fibres which may be seen passing through the parenchyma to be inserted into the dorsal and ventral cuticle, are very delicate and few in number. The transverse muscle fibres which are situated between the medulla and the cortex above and below, and pass out laterally for insertion, are also very weak. The main longitudinal muscles are comparatively small. They are arranged in two concentric sets, each being made up of a large number of small bundles, all of which are about the same size. The whole strobila is thus not very muscular and consequently does not undergo much alteration by contraction. The nervous system consists of a small longitudinal nerve on each side of the strobila in the medulla and just external to the ventral excretory vessel.

The excretory mechanism is represented by a dorsal and a ventral longitudinal vessel on each side, and by a transverse vessel which connects the ventral vessels of opposite sides, near the posterior border of each segment. No valvular structures were recognisable. The longitudinal

vessels pass down along each side well within the medulla. Both have a round lumen, that of the ventral stem being much greater than the other, and possessing a very well defined margin. The dorsal vessel is quite small in section and is not always readily recognisable whilst the other is. Its position is above and generally slightly inwards from the ventral stem which is situated practically in the middle of the lateral region of the medulla and just internally from the nerve. The two tubes lie close together except in the region of the cirrus sac where they widely diverge, the genital ducts passing between them. The transverse vessels have a lumen as great as that of the ventral vessels. In the younger part of the chain, the excretory canals have a sinuous course (figs. 2, 4).

The rudiments of the genital apparatus appear early as a deeply staining cord of cells situated transversely to the length of the strobila. From this cord the vas deferens, cirrus sac and vagina soon become differentiated, and a little further back the last named may be traced posteriorly to the developing female genital complex. The most conspicuous part of this complex represents the receptaculum seminis, the ovary being small and very slightly branched as it does not become nearly as deeply stained as the vitellarium it may easily be overlooked (fig. 2).

By this time the testes have appeared though they are few. They now increase in number and size and are arranged in a layer situated in the dorsal region of the medulla. Their form is spheroidal and their average size in sexually mature segments is about twenty-two micra long by thirteen broad. In transverse sections, they are seen to occupy about two-thirds of the dorso-ventral diameter of the medulla. The number increases from about thirty in young segments to about ninety in those which are mature. The vesicles are disposed laterally and

consequently there are two testicular fields each containing from forty to forty-five testes, whilst the middle of the segment is usually free from them (fig. 4). The cavity of each testis is continuous with a delicate vas efferens. The vasa efferentia ultimately unite to form the large vas deferens, a thickwalled, muscular structure, at first not coiled, but later becoming a greatly convoluted tube lying immediately internally to the cirrus sac and situated medianly in the medulla just behind the middle of the segment. It becomes very considerably distended by the sexual products contained within it. In well stained preparations it appears as a conspicuous organ. It enters the cirrus sac, within which there may be a few more convolutions. There is no distinct enlargement representing a vesicula seminalis.

The cirrus sac is a pyriform body, the narrow end of which is directed laterally towards the genital pore. The walls are thick and possess muscular fibres. In no case was an everted cirrus seen. If eversion is possible, it must be small. There does not appear to be any spines along the end parts of the male duct (fig. 5).

The ovary is a large paired gland situated at the posterior end of the segment and lying behind the testicular fields. The gland lies somewhat nearer the ventral surface. It consists of a rather large stem or bridge of tissue connecting the two glandular parts, and representing a very much enlarged oviduct from which the fairly wide short common oviduct arises to pass backwards to join the fertilising duct. Each glandular portion is made up of a number of blind, more or less dichotomously branching tubes. In some of the older segments the dichotomy is not so recognisable.

The vagina is a well marked duct whose external opening is, in most cases, just posterior to the cirrus. It

travels inwards for some distance at right angles to the long axis of the segment and then curves backwards so as to lie along the midline, and passes dorsally over the common oviduct. It becomes slightly enlarged to form a receptaculum seminis just behind the ovarian "bridge." The vagina now becomes the fertilising duct and passes backwards for a short distance after taking up the common oviduct. Fertilisation of the ova takes place here. The vitelline ducts from the laterally situated vitellaria probably now join it just as it bends round to lie ventrally to its earlier course. Its walls now penetrate the shell gland, a small and inconspicuous organ lying just behind the ovarian bridge. This fertilising canal now passes forwards below the ovary as the uterus. Thus the ovarian bridge or oviduct lies between the vagina (dorsal) and the uterus (ventral).

In some segments, the vagina opens just in front of the cirrus sacs, passes inwards beside it and curves round its inner edge below the vas deferens to occupy its normal course along the middle of the segment. Its position in transverse section is indicated in fig. 4.

The vitellaria consist of two masses situated in an elongate series in the cortex just externally to each longitudinal excretory vessel. Each group extends from near the anterior end to near the posterior end of the mature segments. They are hardly recognisable until the vas deferens has become strongly coiled. The individual follicles are very small and numerous, measuring about seven micra in diameter. They are irregularly rounded or elliptical. Probably the vitelline ducts pass inwards posteriorly to the ovarian lobes and then unite to pass forwards to the fertilising ducts. The vitellaria are not represented in the figures.

The uterus is a thin-walled, long, simple tube lying just below the vagina along the middle of the proglottid and

extending forwards below the vas deferens almost to the anterior end of the segment. Its rudiments occur very early, being present when the vagina has become established. In ripe segments no uterus could be distinguished, the eggs lying in small groups in the parenchyma. This may be the result of the formation of blind pouches which perhaps lose their connection with the uterus. As mentioned before, ripe segments were quite uncommon and consequently I was unable to settle this point. Perhaps segments become detached to undergo fuller development, since in the egg-containing proglottids the whole of the male and female glands and ducts were still fully developed, showing no sign of atrophy, the eggs did not contain hexacanth embryos and the constrictions between the segments were very well marked. The brownish eggs are rounded or elliptical, measuring about 32 by 19 micra. They are relatively few in number. Two shells are present.

The genital ducts pass between the two excretory canals which here become widely separated, each approximating its respective surface. There is no distinct genital papilla, and a genital cloaca is practically absent, the male and female ducts opening almost independently on the surface. The genital apertures alternate fairly regularly in series, three or four usually opening successively on the one side, then about the same number opening on the other side. The openings are usually situated near the junction of the posterior fourth and the anterior three-fourths of the segment, though they may be placed only a little behind the middle as shown in fig. 3.

The presence of laterally placed vitellaria, the absence of a uterine opening, the arrangement of the genitalia and suckers, all indicate that the species belongs to the family Ichthyotaeniidæ, Ariola. If we accept the broad generic characters assigned to the genus *Ichthyotaenia*, Lönnberg,

then this species, for which the specific name *tidswelli* is suggested in recognition of the scientific interest shown by the Directer of the Bureau of Microbiology, Dr. F. Tidswell, must come under this genus.

Prof. S. v. Ratz in a preliminary communication[1] dealing with three new cestodes from *Varanus sp.*, from New Guinea described two species of *Ichthyotaenia* (*I. biroi* and *I. saccifera*) and a *Taenia* (*T. mychocephala*). Unfortunately the fuller descriptions were published in journals[2] which are not available in this State, and consequently I can only compare my specimens with Ratz's unfigured account. However, his descriptions are fairly full and leave very little doubt in my mind that *I. biroi*, *I. saccifera*, and *I. tidswelli* are very closely related. The scolex is very similar in all three, all possessing the delicate covering of spines which do not deserve the name "hooks" given to them by Ratz. The worms are unarmed, since I do not consider a mere raising of the cuticle in the manner described, to be comparable to an armature. Ratz, however, considers the scolex to be armed in his species. *I. biroi* possesses a narrower scolex and more projecting suckers than *I. tidswelli*. The depression mentioned as being present at the apex of the rostellum in the former is absent in the latter. No measurements of the scolex of *I. saccifera* are given. A long neck is present in the first two but practically absent in the last species. The segmentation in our tapeworm is similar to that described for *I. biroi*. The genital openings, however, are differently situated. In *I. tidswelli*, they are not borne on a papilla, and are situated in the posterior half of the mature segments whilst in *I. biroi* and *I. saccifera* they open in front of the

[1] Centrb. f. Bact. I, Orig. xxviii, 1900, p. 657.

[2] (*a*) Arch. d. Parasitol., iv, 1901, p. 329. (*b*) Compt. Rend, Soc. Biol., lii, 1900, p. 980. (*c*) Különlenyomat a Potfüzetek, lvii, 1900, p. 22.

middle of the pore-bearing edge, on a small papilla. The alternation is similar in each. The whole of the male and female genitalia with their accessory organs, do not show any important differences in the three species, except that the vagina opens in front of the cirrus in *I. biroi*, whilst it may or may not do so in *I. tidswelli* and *I. saccifera*. Ratz states that the vitellaria occupy a wide zone in *I. biroi*, whereas they form a very narrow and inconspicuous series in our species. The cirrus sac is pyriform in *I. tidswelli*, roundish in *I. saccifera*, and cylindrical but somewhat swollen on its inner half in *I. biroi*. The ovary is branched in *I. tidswelli* and *I. biroi* but not in *I. saccifera*. The uterus in the last species is widest immediately in front of the ovary, whilst in the other two, it has a fairly regular lumen and forms egg-pouches. It will thus be seen that the cestode from *Varanus varius* approaches *I. biroi* in most of its characters.

The description of *Taenia mychocephala* is too short to allow of its systematic position being assigned with certainty.

In 1903 Dr. von Linstow[1] described a cestode from a Ceylon Monitor, *Varanus (Hydrosaurus) salvator*, under the name of *Acanthotaenia shipleyi*. Having only a single mounted specimen, he was unable to section it, and consequently the description is incomplete. However, the parasite possessed certain well marked characters which led him to make it the type of a new genus, *Acanthotaenia*, with the following characters; the cuticle of the scolex and of the anterior part of the body densely covered with fine bristles; the rostellum unarmed; genital openings lateral and alternating irregularly; testes about fifty in each segment; segmentation hardly distinguishable externally.

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[1] (*a*) Centrb. f. Bact., I, Orig. xxxiii, 1903, p. 532; (*b*) Spolia Zeylanica, I, 3, 1903, p. 51.

There is an incomplete account of the genital system and consequently, on the above description, the genus cannot be placed in its true systematic position. Apparently Dr. Linstow was not aware of Prof. Ratz's work. It must be evident from what has been mentioned before, that there are striking similarities in *Acanthotaenia shipleyi*, *Ichthyotaenia biroi*, *I. saccifera*, and *I. tidswelli*. The cuticle, scolex, rostellum, arrangement of the segments and the position of the genital openings, all resemble each other so that they all belong to the one generic type, the imperfectly described genitalia of *A. shipleyi* being somewhat similar to those of the other species mentioned. The actual number of testes is in this case of no value generically, since there is probably an increase in their number as sexual maturity approaches. Hence *Acanthotaenia*, v. Linstow, must either be regarded as a synonym of *Ichthyotaenia*, Lönnberg, or be more fully described and then regarded as a genus allied to the latter and belonging to the same family.

Dr. von Linstow considered his specimen as belonging to the Subfamily Taeniinæ. He did not recognise the true yolk glands, but regarded the swollen mass (*i.e.*, receptaculum seminis, etc.) just behind the ovary as a vitellarium. The figures of his species show it to differ from *I. tidswelli* in possessing a much larger rostellum; testes not in two distinct fields; a crescentiform cirrus; vagina opening in front of the cirrus; and genital openings situated in the centre of the proglottis edge. *Acanthotaenia (Ichthyotaenia) shipleyi* is thus very near *I. biroi*, nearer in fact than *I. tidswelli*.

In none of the species mentioned, except our own, has it been stated that the spines are present on the cuticle lining the cavity of each sucker. Linstow's figure does not show them. If not specially looked for, they are easily overlooked.

The characters of the genus *Ichthyotaenia* as given by Braun[1] are as follows: the presence of a small scolex with four suckers; and there may be a cephalic organ which may be a sucker or a rudiment of a rostellum; it may be covered exceptionally with small spines; neck short or long; segmentation complete; genital apertures marginal and irregularly alternating; no uterine opening; paired vitellaria lying in the sidefields, with numerous follicles; ovary generally bilobed; shell gland lying behind ovary.

It appears to me to be advantageous to restrict this genus by establishing another genus to receive certain species such as those above mentioned, which possess many very constant characters which seem to be of generic importance. It is, therefore, proposed to alter and amplify von Linstow's genus *Acanthotaenia*, thus:—

Scolex rather small, with four rounded suckers and an unarmed, non-retractile rostellum which bears a muscular structure (probably an altered apical sucker) at its extremity; segmentation not generally distinguishable except in mature segments; no overlapping of segments; cuticle of scolex and anterior part of strobila beset with a dense covering of very fine bristles; genitalia single; openings lateral and alternating irregularly; testes numerous, usually in two longitudinal fields lying in front of the ovary; ovary situated in the posterior part of segment, bilobed and usually branched; shell gland behind ovary; vitellaria in two lateral fields in the cortex; vagina opening before or behind cirrus; uterus median and tubular, but may give off lateral egg-pouches; eggs thin shelled; genital ducts passing between the longitudinal excretory vessels.

It will be noticed that, if we neglect the vitellaria, the genus would easily fall into the super-family Taeniidae and family Dilepinidae, Fuhrmann, possibly into the sub-family

[1] Braun, "Cestodes," in Bronn's Thierreich, Bd. iv, 1901, p. 1706.

Dipylidiinae close to the genus *Oochoristica* which also occurs in reptiles.

Dr. Shipley[1] described a cestode *Palaia varani*, from another Monitor, *Varanus indicus*, Daud., captured in New Britain. This tapeworm was made the type of a new genus *Palaia*, which the author stated as being near *Oochoristica*. There does not appear to be any real affinity between it and the *Acanthotaenia* group.

To the genus *Acanthotaenia* as amended, would belong *A. biroi*, Ratz, *A. saccifera*, Ratz, *A. tidswelli*, Jnstn., and the type *A. shipleyi*, v. Linstow, all of which have been taken from species of *Varanus*. The known Australasian lacertilian cestodes now comprise all of these (with the exception of the last), *Taenia mychocephala*, Ratz, and *Palaia varani*, Shipley, *A. tidswelli* being the only one yet found on the mainland of Australia.

In addition to the tapeworm, there were present a few specimens of a nematode *Physaloptera sp.*, perhaps *P. varani*, Parona, but I have not yet seen a description of the latter, and consequently cannot identify it with certainty. Its habitat was the stomach.

The type slide of *Acanthotaenia tidswelli* has been presented to the Trustees of the Australian Museum, Sydney.

In conclusion I desire to thank my friend, Mr. S. J. Johnston, B.A., B.Sc., of the Biology Department, Sydney

[1] Shipley, "Entozoa," in Willey, "Zoological Results," part v, 1900, pp. 548 – 550. In the description there is no mention of a locality, but on p. 551, mention is made of a cestode *Phyllobothrium dipsadomorphi*, Shipley, infesting a snake, *Dipsadomorphus irregularis*, Merrem., the snake and the lizard being collected from the same locality in New Britain. I have seen *Varanus indicus* near Gladstone in Queensland, and hence it may be expected that before long both *Palaia varani*, Shipley, and the nematode *Physaloptera varani*, Parona (also recorded by Shipley as occurring in this lizard in New Britain) may be added to our known Australian entozoan fauna.

University, for sending me some segments which he had collected in this State from a similar host.

Reference to Plate IV.

Ap.m. apical muscle plug; *b.m.* basement membrane; *c.* cortex; *ci.* cirrus; *c.s.* cirrus sac; *cu.* cuticle; *d.v.* dorsal excretory vessel; *g.* anterior end; *k.* posterior end; *l.m* longitudinal muscle bundle; *m.* medulla; *n.* longitudinal nerve; *od.* oviduct; *ov.* ovary; *r.* rostellum; *s.* sucker; *sc.* subcuticular cells; *s.g.* shell gland; *t.* testes; *tr.m.* transverse muscle fibres; *tr. v.* transverse excretory vessel; *ut.* uterus; *vag.* vagina; *v.d.* vas deferens; *v.eff.* vas efferens; *v.g.* receptaculum seminis; *v v.* ventral excretory vessel; *x.* neck; *z.* septum between segments.

Fig. 1. Scolex of *Acanthotaenia tidswelli*, Jnstn.
,, 2. Young segments showing excretory system and rudiments of genitalia.
,, 3. Sexually mature segment (considerably flattened).
,, 4. Transverse section of a segment, cut in front of the ovary and behind the vas deferens.
,, 5. Cirrus sac. (Slightly diagrammatic).
,, 6. Female genital complex in part (diagrammatic).

Figs. 1 – 4 were drawn with the aid of a camera lucida. In fig. 6, the common oviduct is not shown, its position being just below the vagina. The vitellaria are not indicated in figs. 3 and 4.

ON THE DISCREPANCY BETWEEN THE RESULTS OBTAINED BY EXPERIMENTS IN MANURING ETC. IN POTS AND IN THE FIELD.

By LIONEL COHEN, Chemical Laboratory, Department of Agriculture, N.S.W.

[Communicated by F. B. GUTHRIE, F.I.C., F.C.S.]

[Read before the Royal Society of N. S. Wales, July 7, 1909.]

THE very marked results produced by the use of certain manures on plants growing in culture pots and the enormously increased yield of crop, not seldom contrast strangely with those from similar experiments using the same proportions of fertiliser, the same variety of plant etc., when carried out in the same soil under field conditions. No entirely satisfactory explanation has, I believe, been afforded of this phenomenon, the whole question being considered, and rightly so, perhaps, as an extremely intricate one, and one in which a large number of mutually interacting physical and chemical forces have to be taken into consideration.

The problem of manuring in the light of water-supply seems to have not received the attention in the observations and researches of many workers that the subject deserves, and the questions of the application of fertilisers to the soil, and of rainfall and irrigation have been studied too much apart, but are really inextricably bound up one in another. It seems to me that a very important factor in the study of this matter has been somewhat overlooked, namely the composition or state of concentration of the solution from which the roots derive directly the nourishment for the plant, in other words the soil moisture.

Water exists in the soil in two states, depending on atmospheric conditions, namely, hygroscopic and capillary, the term hygroscopic being applied to that condensed aqueous vapour which is retained by the soil in a dry atmosphere or absorbed by an artificially dried soil from moist air, and adheres as a film to the soil particles, and the term capillary to the water from rain, irrigation, or upward capillary action from "bottom water" which fills up more or less completely the interstices between the particles. It has been shown by repeated experiments that soil contains water-soluble salts to the extent, in the poorer and richer soils respectively, of between about ·02 and ·05%, which from the method of determination may be assumed to be in a state of solution in the water, hygroscopic or capillary, that the soil contains. Now the amount of moisture varies, of course, to a very large extent in a given soil, according as the weather conditions are rainy or droughty, being sometimes as low (when hygroscopic only) as 2·5% and as high as 40% or more when "wet," that is, saturated with capillary moisture.

Let us now consider the growth of a seed or young plant placed in a nutrient aqueous solution, that is, pure water in which have been dissolved the acids and bases in relative proportions similar to those present in plant-ash, and we find that normal results obtain only when the solution is below a certain limit of concentration, and development becomes more and more retarded as the solution becomes stronger, until the limit of tolerance of that particular plant is reached. Let us say that this occurs when the water contains x% of salts. (The numerical value of the symbol will depend on a variety of factors, such as nature of plant, habit, preponderance of one salt over another, or the presence of one, such as carbonate of soda, which exerts an apparently toxic action on certain crops.) Considering

now the case of a plant growing in a pot kept moist by frequent waterings, we find that if the soil contain ·03% of salts in solution, and also averages about 25% of water, this water from which the plant is feeding will contain ·12% of salts. If then, the pot is allowed to become "dry," that is, to lose about 20% of its water (a common occurrence in droughty weather), the soil moisture then becomes a ·6% solution. We thus see what an enormous alteration in the concentration of the soil water takes place in the ordinary drying of the surface of any soil either in the field or in a pot.

We will take the case of a culture pot in which it is intended to experiment with the manuring of the plant whose limit of endurance is x% of salts, and assume that when allowed to become "dry," *i.e.*, contain about 5% of water, wilting will not occur for a day or so—in other words, that the plant will tolerate a ·6% solution. Therefore x is greater than ·6 by, say a. Let us now add to the pot nitrate of soda or sulphate of potash or other soluble salt in quantity approximating a. Then the plant will be affected by the drying more or less injuriously according as the quantity of manure is greater or less than a.

It is thus seen that under field conditions it is desirable that the value of this factor a should be known, as except under irrigation it is manifestly impossible to be sure that the moisture content will not decrease beyond a certain point. We also see that it is not possible to come to a definite conclusion as to the value of a manure unless we know that the moisture conditions at least, are going to be similar in our practical trial, to those of the few experimental plants. Here it is that the difference becomes apparent between experiments in the pot and in the plot. It is a very easy matter to prevent drying in the former, not so in the case of the same plants in the same soil treated

with similar proportions of manure in the field. The culture pot is under complete control—we see to it that it contains never less than about 20% of moisture, that is that our soil water is not more than a $\cdot 15 + a/4\%$ solution, but what happens on the farm? On many occasions during the progress of a field experiment the moisture goes down to 5%, (causing the concentration to reach x), and here we have a theoretical instance where the development of a crop may be seriously retarded by the application of the same proportion of the very material that under optimum conditions of moisture might produce a threefold return.

As a practical example:—Nobbe, Wolff, and other continental experimenters, have proved that the growth of many farm crops are seriously hindered when the water in which their roots are suspended contains more than ·2% of soluble ash ingredients; this being the case, and supposing that we find a soil to contain ·02% of soluble salts, and we wish to add as a manure for the crop nitrate of soda say at the rate of 2 cwt. per acre, or ·02%. Then we increase the concentration in the following way:—when the unmanured soil contains 20% of moisture the latter holds ·1% of salts, a very favourable medium for assimilation, but by the addition of the manure this figure is doubled and reaches the danger mark quoted above, and it thus becomes evident that in order to get favourable results from this addition, it will be necessary to keep always at least 20% of moisture in the soil, a condition seldom practicable in dry countries. It is possible that in many cases farmers and others have developed an insuperable prejudice against the use of chemical fertilisers, because these had been tried on their land under conditions similar to above.

In his book "The Soil," p. 91, A. D. Hall tells us that Dr. Sachs came to the conclusion, as the results of experiments with plants in pots, that different soils can yield up

to the plant only a certain percentage of their water, basing his opinion on the observation that the plant wilted while the soil still contained a good deal of moisture, in some cases as much as 12%. It was also found, by calculation, that the wilting took place in all soils when the film of hygroscopic moisture had diminished to a certain thickness, viz., about ·00003 inch. Now it has been proved by numerous investigations beyond all reasonable doubt, notwithstanding the opinion expressed by Prof. Whitney, of the United States Soil Bureau, in recent papers to the contrary, that the concentration of the soil moisture is as a general rule much greater in clay soils than in sandy ones, and it is just in these clay soils that Sachs found the disposition to wilt with the greatest amount of moisture, whereas in sands the plants (tobacco in this instance) remained turgid while only 1½% of water remained. Is it not possible that the retarded development and wilting were due to the too great concentration of the salts, manurial and otherwise, in the soil moisture? Again, a good deal of irregularity is noticeable in the results obtained in various parts of the world as to the tolerance of certain crops to injurious salts, such as common salt and carbonate of soda.

It seems to me that the quantity of moisture present in the soil is one of the most important considerations in such experiments, as for instance, a plant would grow as well in a soil, *ceteris paribus*, containing 4% of salt and 40% of moisture, as in one containing 1% of salt and 10% of water. This is a question of great importance in some countries, notably our own, and it may not be out of place to suggest that perhaps if maximum and minimum moisture contents of the soils experimented on were determined, much light would be thrown on the apparent discordance of results obtained in different countries.

There is undoubted evidence that in ordinary soil of medium fertility, the use of soluble fertilisers is without profit, in fact in certain cases positively detrimental, unless a correspondingly large amount of water is used on the growing crop, so as to bring the soil moisture below the maximum limit of concentration during its growth. This is an aspect of the subject of manuring to which too much attention cannot be paid, more especially in the matter of irrigation with saline waters and the correction of their alkalinity, it being borne in mind that we cannot add to the water without increasing the quantity of salts in the soil moisture.

In the foregoing brief discussion of the subject I am sensible of not having introduced any matter entirely new, but have merely endeavoured to apply a few observations made by experimenters in other directions, to the question under consideration, one which has provided a good deal of food for thought, and the importance of which in experimental agriculture can hardly be over-rated.

BOTANICAL, TOPOGRAPHICAL AND GEOLOGICAL NOTES ON SOME ROUTES OF ALLAN CUNNINGHAM.[1]

By J. H. MAIDEN and R. H. CAMBAGE.

[With Plates V, VI, VII.]

[*Read before the Royal Society of N. S. Wales, August 4, 1909.*]

I—THE NEPEAN RIVER TO O'CONNELL PLAINS.

THE terminal point reached by Blaxland, Wentworth and Lawson when they succeeded in crossing the Blue Mountains in 1813, was across Cox's River, and a little to the south of Mount Blaxland. From here to Bathurst the country was subsequently explored by Surveyor G. W. Evans, and the track which he followed was used as the main road for some years, being constructed under the supervision of William Cox[2] and was travelled over by Governor Macquarie in 1815, on the occasion of his visit to Bathurst. Surveyor General Oxley[3] passed along this road in April 1817, when on his way to explore the Lower Lachlan and part of the Macquarie Rivers, having amongst his party Allan Cunningham, King's Botanist, and Charles Fraser, afterwards Colonial Botanist, and both of them subsequently Superintendents of the Botanic Gardens, Sydney.

A more direct road from the vicinity of Cox's River to Bathurst was afterwards laid out by Major Lockyer, leaving the old road near Collit's Inn, at the foot of Mount York, and passing through Bowenfels to Sodwalls and eventually joining the original road at O'Connell Plains.

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[1] For particulars of Allan Cunningham see Vol. XLII, p. 99 (1908).

[2] "Memoirs of William Cox, J.P.," (Sydney 1901).

[3] Oxley's "Journal of Two Expeditions, etc." (London 1820).

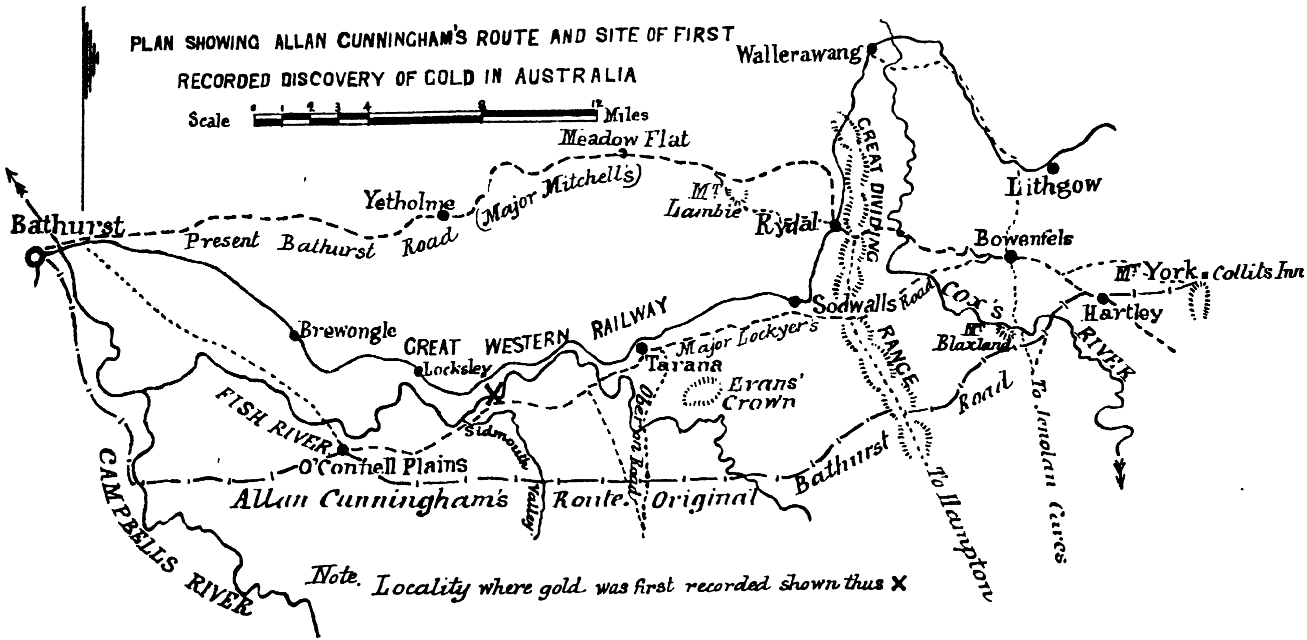
This second road was deviated by Major (afterwards Sir Thomas) Mitchell in the early thirties just beyond Bowenfels, and passed through Rydal, Meadow Flat and Yetholme to Bathurst, and, with some minor deviations, it forms part of the present Sydney to Bathurst road. (See *Plan.*)

Allan Cunningham's MS. Journal of this Lachlan trip (to the "western interior" as it was called), is still in existence. Extracts from his Journal have never before been published, and are of special interest to botanists in that they indicate some of his collecting grounds. We have, at different times, traversed on foot the route from Emu Plains to near Bathurst, not confining ourselves to the modern road, but, rough as it is, have followed his steps accurately. We will defer consideration of the neighbourhood of Bathurst for another paper.

Allan Cunningham had been sent out as King's Botanist by Sir Joseph Banks, and arrived in Sydney on December 21st, 1816. Governor Macquarie requested him to accompany Mr. Oxley in the expedition to which allusion has been made. They crossed the Nepean River on 6th April, 1817, and from the crossing (Emu Ford)[1] distances as far as Mount York were calculated. Cunningham remarked that the banks of the Nepean are "clothed with spreading trees of the *Melia azedarach*, called by the settlers 'White Cedar'" which is interesting to those who look upon it as an introduced tree, which undoubtedly it is in many parts of New South Wales.

Springwood.—Cunningham remarks on the "good pasturage and lofty handsome timber" near the "depôt" at Springwood ($12\frac{1}{2}$ miles from Emu Ford). This is owing to the presence of the Wianamatta shale which overlies the Hawkesbury sandstone. He notes that "*Eucalyptus robusta*

[1] The Ford is now silted up, but a view of it, by Lewin, is in possession of the Antill family.


PLAN SHOWING ALLAN CUNNINGHAM'S ROUTE AND SITE OF FIRST
RECORDED DISCOVERY OF GOLD IN AUSTRALIA
Scale
0 1 2 3 4 8 12 Miles
Meadow Flat
Wallerawang
Lithgow
Bowenfels
Mt York
Collits Inn
Hartley
Yetholme
(Major Mitchell's)
Mt Lambie
Rydal
GREAT DIVIDING RANGE
Bathurst
Present Bathurst Road
Brewongle
GREAT WESTERN RAILWAY
Locksley
Sodwalls
Road
Cox's
River
Mt Blaxland
Major Lockyer's
Tarana
Evans' Crown
Oberon Road
Sidmouth Valley
FISH RIVER
O'Connell Plains
Allan Cunningham's Route. Original Bathurst Road
To Hampton
To Jenolan Caves
CAMPBELLS RIVER
Note. Locality where gold was first recorded shown thus X

(this tree is not present and it is impossible to say to which species he refers, without seeing his specimens), *E. resinifera* and *Casuarina torulosa* are predominant, with another species of Eucalyptus called by the colonists Stringy-bark" (*E. eugenioides*).[1]

The original "spring in the wood" is, according to Major Antill (who accompanied Governor Macquarie in 1815) "about a mile down a deep glen." It is at North Springwood, on the late Dr. Norton's property, and Cunningham collected freely here. It is now almost a quagmire from the trampling of dairy cattle and is overrun with *Polygonum*. *Eucalyptus Deanei* is common about the spring, together with *Eugenia Smithii*, *Syncarpia laurifolia*, *Synoum glandulosum* and *Santalum obtusifolium*. The spring is the head of Fitzgerald's Creek.

With others we joined in the search for the so-called "**Caley's Repulse,**" a name given by Governor Macquarie on his journey over the Blue Mountains in 1815, to a cairn of stones erected by an early explorer. One of us, at pp. 133 to 138 of "Sir Joseph Banks: the Father of Australia," has given the history of this Cairn, and Cunningham refers to it. He says it is "near the 18th mile-mark," and at another place states that it is 6 miles from Springwood and 8 miles from King's Tableland. Near the bend of the road past Mr. Baynes' house (on the hill beyond Linden) is the mile-stone "5½ miles to Springwood," so "Caley's Repulse" was somewhere about here, *i.e.*, between here and Woodford. Some allowance may, however, have to be made from the points at which mileages from Springwood were measured in Cunningham's and our own day.

Cunningham tells us that "*Persoonia* (?) *microcarpa* (*P. microcarpa* is a West Australian plant), a tall shrub, is

[1] See a paper by the authors "Notes on the Eucalypts of the Blue Mountains." *Proc. Linn. Soc. N.S.W.*, xxx, 190 (1905).

frequent near Caley's Repulse" (this is *P. pinifolia*, R. Br.), and that a "*Styphelia* (closely allied to *S. reflexa*, Rudge) but having a much longer style and mucrone to apex of leaf" is also found there. This is perhaps *Leucopogon collinus*.

The King's Tableland (in the vicinity of Wentworth Falls) is 14 miles from Springwood, 26 miles from Emu Ford and this plain, so named by Macquarie, was "considered as the summit of the Western Mountains." It is 8½ miles west of the "Bluff Bridge" which, Antill says, was half a mile beyond Caley's Repulse, and consisted of an extemporised bridge across a chasm. Cunningham collected freely here in "brushes," "margins of peaty bogs," and "margin of the Cascade," "Ravines," besides on the "King's Table-land" proper.

Regent's Glen.—Cunningham collected on the "verge" or "rocky verge" of this glen. What we know at the present day as the Falls or Great Fall at Wentworth Falls is "The Campbell Cataract" of Macquarie, in honour of the maiden name of Mrs. Macquarie, and not of the Colonial Secretary of the period. The name has gone out of use, but it is used in Cunningham's Journal. The "Regent's Glen" or "Prince Regent's Glen" is a north-westerly ravine extending from its intersection with the main Kanimbla Valley back to an abrupt rocky end in the neighbourhood of Campbell's Cataract.

Weatherboard Hut.—At the 28 miles (from Emu Ford) they arrived says Cunningham "at a wooden house, erected originally as a store for the preservation of provisions for the use of the men working along the road,[1] and now converted into a Half-way House. This is the celebrated structure whose name is even yet familiar to older people

[1] Under William Cox, *supra* p. 123.

as the "Weatherboard Hut," the name universally in use until Wentworth Falls was adopted for the locality.

"Some boggy slopes at the back of our wooden house have been called **Lewin's or Jamieson's Plains.**"

It is in the vicinity of Wentworth Falls that most of the notes by Cunningham in regard to specific Blue Mountain plants were made.[2]

Pitt's Amphitheatre.—This is another collecting ground of Cunningham, 5 miles from the Weatherboard or 33 miles from Emu Ford; it is a sweep of the Kanimbla Valley, and faces Campbell's Cataract (Wentworth Falls). He observes that he did not notice *Lambertia formosa* further west than about the 32 mile mark.

Blackheath.—" We arrived at an open but low bushy tract of country which His Excellency (Macquarie) had named (in 1815) Hounslow Heath, although it is frequently called Black Heath. Halted to-day in this heath, near the 41 mile mark. The water here is far from being good, being the drainings of the low black peat, which constitutes the soil of the slopes from the heath."

It was in these "spongy bogs" that Cunningham found his new species of *Grevillea* (*acanthifolia*). Here he records having got seeds of the *Eucalyptus*, afterwards named *stricta*, "a small tree not exceeding 14 feet, forming a close brush, and covering the whole of the Heath and the mountains to the eastward."

Mount York.—This place is important for botanical and other reasons. Cunningham collected freely in the vicinity. Here is what he terms the "abrupt termination of the Mountains," Cox's Pass, the Vale of Clwydd, and here starts (inconveniently decreed by Macquarie) the third

[1] The name of *Eucalyptus stellulata* should be added to our list of Eucalypts on the Blue Mountains, as it occurs close to the railway line a few hundred yards beyond Wentworth Falls Station.

series of mile-marks between Sydney and Bathurst. This is also a well-defined botanical boundary, for we have hitherto been traversing the sandstone, with its showy flora; we now (at Cox's River) get on to the granite with its larger trees (except in the sandstone gullies), and very much sparser flora. Let Allan Cunningham speak :

"Here was observed the very remarkable change of country, differing from that on the mountains both in the vegetable productions and nature of soil. The *Banksia serrata* ceases to exist further westerly than the summit of Mount York, and *B. compar* (*B. marginata*, is really meant), succeeds, throughout the Vale (Clwydd). *Eucalyptus perfoliata* of Kew Gardens is very frequent, and another species with cordate sessile leaves, and others lanceolate and inserted on a petiole." (Doubtless *E. dives* and *E. Gunnii* var. *rubida* are referred to).

He collected freely in the Vale and at five miles (from Mount York) arrived at Cox's River. "About three miles to the westward of Cox's River, where is a depôt and storehouse, three remarkable hills present themselves connected together. The Governor has called them Mount Blaxland, Wentworth's Sugar Loaf and Lawson's Sugar Loaf." It is about Cox's River and Mount Blaxland that Cunningham made perhaps the most interesting collections and most detailed botanical notes between Sydney and Bathurst. They are dealt with in his Journal, and some of his scientific results are published in a volume[1] which is of especial interest to our members, since it contains the only records we possess of the Proceedings of the Philosophical Society of Australasia (founded in 1821), of which our Society is the lineal successor.

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[1] "Geographical Memoirs on New South Wales"; Barron Field (1825). Practically the whole of the plants enumerated by Allan Cunningham in this work as having been collected by him along the route referred to in the present paper were collected by us and are now in the National Herbarium, Sydney.

On the top of Mount Blaxland we collected *Eucalyptus pulvigera* and *haemastoma*, *Acacia verniciflua*, *Brachyloma daphnoides*, *Dodonœa attenuata*, *Grevillea triternata*, *Stypandra glauca*, *Eriostemon myoporoides*, and *Helichrysum bracteatum*. The remarkable *Eucalyptus pulvigera*, discovered and named by Cunningham, and existing in very few localities, as far as known, is a feature of the hills named. The easiest way to reach Mount Blaxland is by train to Bowenfels, and then drive (five miles).

Clarence's Hilly Range.—We now ascend "a range of hills of difficult and fatiguing ascent, which the Governor has named Clarence's Hilly Range." Clarence's Hilly Range does not occupy much attention in Cunningham's Journal; this is accounted for by his references to the arduousness of the journey, such as "very severe and oppressive to our horses, the whole being sharp, lofty hills, and narrow boggy valleys alternately," and the comparative monotony of the vegetation.

As far as Mount York, the road is familiar to many people (parts of it, at least), for the way over the Blue Mountains follows a ridge, and one cannot get very far off the road. But we have walked over every foot of it and have traced the various deviations of the road necessary in a century's development. But when we come to Cox's River, the modern Bathurst road is very different to that of the old track which Allan Cunningham followed over "Clarence's Hilly Range." The modern road goes to the right by a scientifically graded path; the old track is a dangerous road, in parts, with practically no settlement upon it, and it can only be found by close attention to the Parish Map, accompanied by technical knowledge. The best way to get on to the track is to make Rydal the temporary headquarters, then drive along the Hampton road for 8 miles. On the left hand side is a gate opposite marked tree, broad

arrow over E over 91. On our way to Mount Blaxland we cross Mary Ann's and Jock's Creeks. There is no bridge over the latter, as stated on the map, and the descent into it is severe.

The trees between Mount Blaxland and the present Rydal-Hampton road are *Banksia marginata*, *Exocarpus cupressiformis*, *Eucalyptus melliodora* (near Mount Blaxland), *stellulata* (at the creeks), *viminalis*, *regnans* var. *fastigata* (two trees seen between Mary Ann's and Jock's Creeks) *coriacea*, *amygdalina*, *dives*, *Gunnii*, var. *rubida*, and *Stuartiana*, *Acacia decurrens* var. *dealbata*, *melanoxylon* and *penninervis*, *Casuarina suberosa*. Innumerable individuals of the little yellow-flowering shrub, *Hibbertia linearis* var. *obtusifolia* were in full flower in the district in April. Rydal may again be reached by continuing the old road as far as Mount Blaxland and crossing over Cox's River, then viâ Bowenfels village along the new Bathurst road to Rydal.

To continue Cunningham's track in the direction of Bathurst we drive again from Rydal eight miles along the Hampton road and turn to the right. Its (western) gate is about 200 yards north of the gum tree marked broad arrow over E over 91. The trees on the stage to Fish River are much the same as those from Mount Blaxland to the Rydal-Hampton road. We took a sulky, but found Clarence's Hilly Range as steep as Cunningham described it, and recommend the journey to be undertaken on horseback.

The Fish River.—A crossing over this river was a stage (on the Oxley-Cunningham Expedition) and hence plants were collected in the vicinity and notes made. A little further the picturesque amphitheatre of rocks called by Macquarie "Mount Evans," and now "Evans' Crown" comes into view. At the back of this (*i.e.*, on its convex

side), is Tarana. On the last slope descending into the Fish River are noticed *Eucalyptus melliodora*, *Indigofera australis*, *Xerotes longifolia*, *Hardenbergia monophylla*, *Cassinia quinquefaria*.

The crossing of the Fish River is awkward to approach owing to its proximity to Hobby's Creek, but is not dangerous (*Plate* 5). It was not more than twenty yards wide when we crossed it (April, 1909) and in it are small islands with *Arundo phragmites*. Around the crossing are *Acacia decurrens* var. *dealbata*, *Eucalyptus viminalis*, *melliodora*, *Stuartiana*, *Gunnii* var. *rubida* and *stellulata*, *Xerotes longifolia*, *Rubus parvifolius*, *Stellaria pungens*, *Leptospermum flavescens*, *Callistemon paludosus* and *Lomatia longifolia*. In the water was *Potamogeton tricarinatus* and *Polygonum hydropiper*. Sweet briar is in the greatest profusion. We were surprised that we could see no sign of *Casuarina Cunninghamiana* lining the banks of the Fish River as far as our vision extended. After passing the Fish River, *Swainsona galegifolia* was not rare, and this is probably the supposed "Indigofera" of which Cunningham speaks in his Journal. (*Indigofera australis* has already been noted). After a somewhat steep hill we cross the Tarana-Oberon road. Here it is five miles to Tarana, where we put up for lodging.

Resuming our journey from Tarana, we proceeded along the old Oberon road for about two and a half miles, where there is a sign-post, "O'Connell 10 miles," and soon cross the Fish River once more, and shortly afterwards meet *Eucalyptus tereticornis* for the first time since Penrith, a sure sign that we are descending. At four miles from Tarana along the O'Connell road, we see *Eucalyptus Cambagei* for the first time. In a little distance we are abreast of Sidmouth Valley, say a couple of miles to the left. We turn off here to the scene of Surveyor McBrien's gold

discovery in 1823 (see below, p. 137). The trees in the vicinity are *Casuarina Cunninghamiana*, *Leptospermum flavescens*, *Eucalyptus Stuartiana* and *viminalis*, and *Acacia decurrens* var. *dealbata*. Arrived back on to the road, in another mile we cross the Sidmouth Valley Creek which flows into the Fish River a few yards away. *Datura tatula* is in surprising abundance about here, and there is a sprinkling of *Echium violaceum*.

A mile further on we come to Rainville Creek. Say one mile beyond this we passed through sliprails to the left at Portion 164, followed the fences easterly for under half a mile, then passed through sliprails on the right into a beautiful open paddock for say three-quarters of a mile when we came to a weak place in the fence and got into the old Bathurst road once more. We have gone into details as the road is not easy to find if the site of the first gold discovery be included in the trip. Thus we were once more on Allan Cunningham's track, and this track meets the Tarana-O'Connell road (along which we had been travelling) at O'Connell, four miles further on; we were say three quarters of a mile west of Rainville Creek.

Proceeding east (*i.e.*, going back in the Fish River direction) we arrived at Sidmouth Valley, which, though not an extensive one, is very beautiful, and has rich black soil flats. At two miles from the Oberon road, we found the only *Eucalyptus macrorrhyncha* trees we had seen on the trip. In one and a half miles from this we cross Snakes' Valley Creek and in half a mile cross the old Oberon road (from Mutton's Falls). Crossing the road, in another quarter of a mile we come to the new Tarana-Oberon road, at a place five miles from Tarana. Here the prospect is extensive, and one can view for at least half a mile the old Cunningham track in the direction of Fish River.

Sidmouth Valley.—Turning back to Sidmouth Valley, following is what Allan Cunningham says of it:—

"Eight miles west of Fish River is a fine spacious valley running N.W. and S.E. bounded by hills of easy ascent and thinly covered with timber. This vale, which the Governor called Sidmouth Valley is an exceedingly fine and rich grazing spot."

The soil is too rich to have much variety of plants. Cunningham proceeds to say "Onward, diminutive forest lands prevail, which are open rising grounds, and fine grassy plains." Going westerly from Sidmouth Valley, we approach O'Connell Plains and are in the Bathurst district.

* * * * * * *

We found *Banksia marginata* (Honeysuckle) was common along the roadside, but strictly confined to the granite formation. It was absent from those parts of the Main Divide which were covered by the Devonian conglomerates, and being a lover of sandy soil, its advent was a sure indication of the presence of the granite.

Casuarina Cunninghamiana (River Oak) while absent from the old crossing place on the Fish River and for a mile or so below, was exceedingly common along the banks from the Oberon road to O'Connell. The species seems unable to withstand extremes of heat and cold, and probably its absence from the upper parts of the river is owing to the more rigid conditions of climate. After the Fish River joins the Macquarie the River Oaks continue, and are found some distance below Dubbo, but cease before the Macquarie enters the reed beds where the channel is lost. As an evidence of the effect of aspect upon certain species of our native flora, some of which prefer an eastern or moist climate, while others favour a western or dry atmosphere, it was noticed that *Eucalyptus amygdalina* (Messmate or Peppermint) gradually disappeared after the Main Range was crossed, while *E. dives* (Peppermint) occurred at intervals the whole way, and is known to be common as far west as Orange. Though both are mountain species,

the former slightly favours the eastern aspect, and the latter the western.

Geological Formation.—About two and a half miles to the south of Bowenfels, Cox's River has entrenched itself through a mass of aplitic granite, leaving steep walls of 600 or 700 feet high on either side, the bed of the river being about 1,000 feet below the village. The eminence thus formed on the southern side is known as Mount Blaxland, and being steep and somewhat rounded, presents a remarkable appearance when viewed from the valley, and according to the records, was an object of interest to the early travellers. It is perhaps most attractive, however, from the south-western side at a point a mile or so along the old road where it stands out as a beautiful cone.

From Cox's River to O'Connell the geological formation consists of granite, practically the whole way. Passing to the south of Mount Blaxland, the road bears south-westerly over several spurs, and in about six miles, after ascending more than 1,000 feet, reaches the top of the Main Divide. The road continues on a south-westerly course till the vicinity of the Fish River is reached, and bears thence westerly to O'Connell. The summit of the Main Range where crossed, is capped with Devonian conglomerate, as also is the ridge previously crossed, and which divides the waters of Jock's and Mary Ann's Creeks. This old road intersects that from Rydal to Hampton at about eight miles south of Rydal (*supra*, p. 130). The latter road follows the summit of the Main Divide, which is for the most part covered with the Devonian formation, though in places this has been removed by denudation and the granite laid bare.

It seems probable that the presence of this Devonian conglomerate has been an important factor in determining the position of the Main Range at this point, as, owing to

its hard nature, it has tended to protect the granite from weathering and being removed by the action of water. It was noticed at several points along the track, where sections of the formation were visible, that the granite was decomposed *in situ* to depths of 10 and 20 feet, or as far down as the rock was exposed. It is not surprising therefore to find the country much dissected into deep valleys, and the name of Clarence's Hilly Range, which was bestowed by Governor Macquarie on the area between Cox's River and the Main Divide, was suggested by the number of steep ridges encountered. A few hundred yards beyond the summit of the Main Range the Devonian formation ceases and is not met again the whole way to O'Connell, or even to Bathurst, though northerly from Rydal it is well known to extend over a very large area. It is significant, however, that in crossing the Fish River, some five or six miles south-easterly of Tarana, typical Devonian fossils (*Spirifer disjuncta*) were found in some of the water-worn stones forming the shingle beds along the banks, thus proving that the river drains a Devonian area to the south.

About three miles northerly from this old crossing are the remarkable granite rocks known as Evans' Crown, or Peak (in some maps) and which have been left on the summit as residuals, while the adjacent formation decomposed and weathered away. Although this crown is well seen from the railway line near Tarana, it presents a more majestic appearance when viewed from the southern side, where Evans first saw it. The valley of the Fish River, as it sweeps round to westward under the hills, forms a sort of amphitheatre in the foreground, and with some additional rocks, not seen from the northern side (one of which is suggestive of a gigantic pelican in an attitude of semi-repose), lends an additional grandeur to the scene.

Sidmouth Valley is composed of black soil derived from the decomposition of some basic rocks on the mountains to the south, and before being cleared, it probably supported a vegetation differing somewhat from that of the surrounding granite hills. At the point crossed it is what the physiographer terms an immature valley, owing to its steep sides, but develops into a broad mature valley lower down.

First Official Record of Gold in Australia.—The road again meets the Fish River at O'Connell, and at a point on the opposite side of the river about six miles above this little village is the site of the first officially recorded gold discovery in Australia. In the Mines Department Annual Report for 1877 (p. 202) Mr. C. S. Wilkinson, F.G.S., Government Geologist, refers to the first discovery of gold, and mentions the record by Assistant Surveyor McBrien in his field book, as the earliest notice on record of the discovery of Gold in Australia. The entry was made by Surveyor James McBrien when surveying the Fish River, and is dated 15th February, 1823. The entry reads:—"At this place I found numerous particles of gold in the sand in the hills convenient to river." The field book is still in the custody of the Department of Lands, but a facsimile of the page recording the discovery may be found in "The Mineral Resources of New South Wales" by Mr. E. F. Pittman, A.R.S.M., Government Geologist.

In March, 1909, Mr. Licensed Surveyor T. G. Wilson, Sr., having some leisure at his disposal, obtained a copy of the field book with which he proceeded to the district, and by making a re-survey established the position indicated by Mr. McBrien. From Mr. Wilson's study of the field notes he concludes that the sign like an 8 or an & after the word "at," which occurs so many times, means "end of line." The remainder of the particular entry referred to would

therefore signify an offset, and would read:—"At end of line, 1 chain 50 links to river and marked gum-tree." The locality of the first official record of gold in Australia has been fixed by Mr. Wilson on portion 42 Parish of Eusdale, Country of Roxburgh.

The spot is nearly a mile and a half above the junction of Sidmouth Valley and the Fish River, or a little more than a quarter of a mile above the residence of Mr. W. R. Hutchison, the owner of the property. It is about midway between Tarana and O'Connell, and three miles above Locksley. The original survey followed the right bank of the river (*Plates 6 and 7*). The geological formation for some miles around the locality is granite, over which area gold in limited quantities, has from time to time since been won. The small boulders brought down from the Devonian country towards Rydal may be found in the river, and also on the sides of the granite hills, at elevations sufficient to show that in pre-historic time the bed of the river was from 100 to 200 feet above its present level.

Explanation of Plates.

Plate V.—Site of first bridge over Fish River.
,, VI.—Site of first recorded gold discovery in Australia.
,, VII.—Locality of first recorded gold discovery in Australia.

ON A NEW GENUS OF BIRD-CESTODES.

By T. HARVEY JOHNSTON, M.A., B.Sc., Assistant Government Microbiologist.

(From the Bureau of Microbiology, Sydney, N.S.W.)

[With Plate VIII.]

[*Read before the Royal Society of N. S. Wales, September 1, 1909.*]

IN May 1894, Professor J. P. Hill collected some entozoa from birds in the Jervis Bay district, amongst them being a single specimen of a cestode taken from the intestine of a bird which he has indicated as a "Jaby, a bird like a crane." Mr. S. J. Johnston, B.A., B.Sc., to whom Dr. Hill gave the specimen informed me that the bird in question was very probably the Jabiru, *Xenorhynchus asiaticus*, Lath. This is the only Australian representative of the family *Ciconiidæ* which includes the Storks. It occurs on the Clarence River, (N. S. Wales), in Queensland, in Northern Territory, and in North-west Australia, its occurrence as far south as Jervis Bay being rather unusual.

Unfortunately there was only a single, unstained, mounted specimen, but it possessed such striking characters that I ventured to strip it carefully and then stain it, using haematoxylin after having failed to colour it with borax carmine. I was not able, therefore, to make any sections.

The entire strobila is very small, consisting of a comparatively prominent scolex and some fifty-four segments which together only reach a length of about sixteen millimetres.

Scolex:—When examined in face view, the scolex appears to be roughly rhomboidal with the posterior corner truncate (*Plate 8*, fig. 2). Its length from the apex to the first

segment is 0·225 mm., its greatest width (excluding the suckers) being 0·187 mm., or 0·226 mm. if we include them. The width at its posterior end is only 0·072 mm.

The rostellum is distinct but short, merely forming the anterior corner of the rhomb. On its apex there is present a more deeply staining disc resembling the apical or rostellar musculature of some other tapeworms, and to it are attached the circlet of hooks. In its centre there is a shallow rounded depression which lends to the opinion that the rostellum is retractile. The organ is not sucker-like. The hooks are arranged in a single circlet of about fourteen. They are comparatively long, thin and prominent, measuring about forty millimetres in total length. The anterior attachment or handle is rather pointed at its free end and only gradually widens towards the guard. It is fairly long (11μ). Its shape is seen in *Plate* 8, fig. 3. The guard is rather prominent and is regularly rounded. The shaft is by far the longest part of the hook, reaching a length of nearly thirty micra. There is a gradual narrowing until a delicate strongly-incurved extremity is produced.

The four suckers are distinctly projecting, muscular, unarmed organs arranged as a pair on each flat surface. There is only a narrow but comparatively deep depression between each pair. The apertures are directed antero-laterally and measure nearly 0·1 mm. in diameter. The surrounding muscular rim is prominent.

Strobila:—The head becomes narrowed posteriorly to join the segmented part of the strobila. There is no unsegmented neck region, the proglottids commencing immediately behind the scolex. The segments alter considerably in shape and size in different parts of the chain. The first few are many times broader than long; beyond this the segments gradually lengthen into a shape resembling a short bell, the posterior edge of each overlapping the anterior

edge of the succeeding segment only to a moderate degree. Then follow more or less triangular, but still somewhat bell-like segments of relatively considerable length with a delicate anterior and a wide posterior end, the latter projecting very markedly and overlapping the front of the next proglottid. There is now a rather quick decrease in the relative length and an increase in breadth. It is in this region that the genital glands become distinctly recognised, their rudiments appearing in the more elongate segments lying more anteriorly. By this time the bell-shape has become lost and there is now very little overlapping of the now broad anterior portion of each joint by the preceding one. The segments then increase very rapidly in both diameters until the ripe segments are reached, the measurements now remaining fairly constant, the length being about 0·55 mm. and the breadth 0·75 mm. These larger proglottids are only slightly connected with each other.

As mentioned previously, the specimen being unique and in addition, being very small, no part could be sacrificed for sectioning. Consequently very little can be said of the histology and of the position of the excretory canals, nerves, etc.

The cuticle is about two micra in thickness. Below it lie the small subcuticular cells. The longitudinal muscle fibres are only moderately developed. No part of the nervous system could be detected. The only portion of the excretory system recognisable was seen in the region of the developing genitalia. The vessels lie just laterally to the vas deferens on the one side, and in a corresponding situation on the other side. Their position is indicated in the semidiagrammatic fig. 4. The parenchyma appears to be finely granular, but this may not be natural. There are in it numerous oval or rounded calcareous corpuscles from

five to fourteen micra long by from five to seven micra broad. In ripe segments, these bodies are abundant except at the anterior ends around the retractor muscles of the cirrus.

Genitalia:—The genital openings are all placed on the right side. In matured segments, they appear as large cup-shaped depressions with a crenate rim, situated on a very bulky genital papilla which lies near the anterior margin of the segment close to the posterior border of the preceding segment. When the cirrus is everted, the papilla is very prominent.

The genital rudiments may be recognised fairly early as a longitudinally placed mass of cells, somewhat spindle-like, situated in the middle of the segments. Later, the posterior part of this cord differentiates into the small rounded testes and the female complex. The male glands are now seen as a circlet of six vesicles surrounding the developing female glands (*Plate 8*, fig. 4). Each testis is about 10 by 8μ. The middle and anterior parts of the cord, especially the latter, now become enlarged and develop ultimately into the female and male ducts respectively. The female glands now increase considerably in size. The vagina, the vas deferens and especially the cirrus with its sac become very prominent structures, the cirrus now possessing its characteristic internal covering of bristles arranged with their free ends pointing outwards. By this time the ducts can be traced to the genital opening.

The testes are very few in number, only seven or eight being present. They lie rather more dorsally than the female complex. Their arrangement is very characteristic, six vesicles forming a ring around the immature female glands. This recalls the arrangement described by Prof. Fuhrmann[1] as occurring in his genus *Cyclorchida*. The

[1] Fuhrmann, Centrb., f. Bact. u. Par., Orig., I, XLV, 1908, p. 525; *id.*, Zool. Jahrb., Supp. Bd., X, I, 1908, p. 62.

other vesicles are situated more anteriorly and lie in the medulla on the side remote from the pore-bearing edge and just internally from the excretory vessel of the corresponding side (fig. 4). By the time that the ovary is matured, the testes have already begun to abort.

The vas deferens is a fairly well marked tube also lying on side remote from the pore-bearing edge. It is rather wide and somewhat coiled. After passing forwards close to the excretory vessel it then travels across the segment to enter the cirrus sac. Just before its entry there may be a slight enlargement representing a vesicula seminalis.

The cirrus sac is a very large, powerful organ, at whose inner end is a strong mass of muscular tissue constituting a cirrus-retractor muscle. One can scarcely differentiate between a cirrus and a cirrus sac, though I am using the latter term to distinguish that part which lies nearest the genital pore and is not eversible. The cirrus appears as a comparatively long strong walled structure forming the continuation of the vas deferens. Its walls are beset with a dense covering of bristles whose points are directed outwards while the cirrus is at rest, but when the organ becomes everted these spines come to lie in such a way that their points are backwardly directed. Each spine is then seen to be comparatively large and strong and to resemble a rose thorn in shape, its base being about $3{\cdot}5\mu$ in diameter and its length 10μ. On the swollen basal part of the cirrus, there are a great number of closely set spines of the same shape but of larger size than those on the other part, their measurements being about 7μ at the base by 17μ in length. There is no appearance of special spines such as those described as occurring at the base of the cirrus in *Acanthocirrus*. Perhaps one should consider the greatly elongated muscular structure which forms a narrow sheath around the inner parts of the retracted cirrus as

being part of the cirrus sac. When the organ is fully everted it extends at least 0·3 mm. Even then a considerable part of the bristled wall still remains within the cirrus, as is shown in fig. 5. In younger segments the organ may be curled at its inner end. The cirrus lies dorsally to the vagina, its opening being just above and in front of the female pore.

The vagina is an exceptionally wide tube, occasionally twisted, with very well defined walls containing some longitudinal muscles. It courses inwards and backwards to the middle of the segment. Its inner end may be slightly swollen and rounded, but as a rule a receptaculum seminis cannot be distinguished.

The ovary is a distinctly bilobed, somewhat branched organ lying just behind the midregion of the segment. Though very small at the time when the testes are approaching their full development, it rapidly increases in size and appears to dwindle again very soon. The description of the female complex is unfortunately not as complete as I would like, but the parts are very hard to distinguish. The rapid growth of the uterus obscures these parts. Neither oviduct nor shell gland are recognisable. As mentioned above, the developing ovary is encircled by the testes.

The vitellarium lies near the posterior edge of the segment as a rounded organ. From it there passes forward a delicate vitelline duct which enters the inner end of the vagina, or as it ought perhaps to be called here, the fertilising duct, just before it opens into the uterus.

The uterus appears rather late but it develops very rapidly, becoming filled with eggs and then assuming a simple sac-like form which it retains. When ripe it almost fills the segment, the vagina, cirrus sac and its muscular system however, still persisting. The fertilising duct

enters it at about the middle of the proglottid. Though the uteri are crowded with ova in various stages, no details could be satisfactorily made out in regard to the eggs and oncospheres.

Systematic position:—The sac-like character of the uterus and the general organisation of the whole worm, indicate that it belongs to Fuhrmann's[1] family *Dilepinidæ* and to his subfamily *Dilepininæ*. However, it possesses some very striking features which do not allow of its inclusion in any of the known genera. It is therefore pro-poposed to erect for its reception, a new genus, *Clelandia*, in honour of my colleague at the Bureau, Dr. J. B. Cleland, who has shown a very keen interest in parasitology, both in Western Australia and in this State. The characters of the proposed genus, based on its type species *C. parva*, sp. nov., may be stated as follows:—Scolex with powerful unarmed suckers; rostellum with long hooks arranged in a single row on an apical disc; genital pores unilateral; genitalia single; testes few in number and forming a circle round female genitalia; cirrus large and provided with powerful spines, especially on the base, but all of practically similar shape; mature uterus sac-like and nearly filling segment.

The possession of unilateral genitalia separates this new genus from other genera in the same subfamily possessing alternating pores, e.g., *Amœbotænia*, *Fuhrmannia*, *Anomotaenia*, etc., whilst the presence of a single circlet of hooks on the rostellum separates it from allied genera with unilateral pores, e.g., *Dilepis*, *Cyclorchida*, etc.

The main distinguishing characters of *Clelandia* lie in the male genitalia and the rostellar hooks. The arrangement of the testes in a circlet around the female complex only

[1] Fuhrmann, Die Cestoden der Vögel in Zoolog. Jahrb., *loc. cit.*, p. 51.

occurs, as far as I know, in *Cyclorchida*, but this genus possesses a great number of these vesicles (about ninety), and a double circlet of rostellar hooks of a characteristic form viz., there is a powerful base and a small hook part. There is thus very considerable and important differences between these two genera. Though the cirrus sac is beset with strong spines in both, yet the details of this organ are different in each genus.

The other nearly related genus is *Acanthocirrus*, Fuhrm.[1] in which there is no mention of the arrangement of the rostellar hooks, consequently we cannot compare in this direction. The male organs however are quite different to those of *Clelandia*, since the testes, though few in number, are not arranged around the female glands but are situated behind them in the posterior half of the segment. The cirrus and vagina show considerable resemblances to those of our genus, but the large characteristically shaped spines lying in special pouches at the base of the cirrus in *Acanthocirrus* are not present in *Clelandia.*

It appears, therefore, that the new genus lies between *Cyclorchida* and *Acanthocirrus* and approaches more nearly to the former, if we exclude the shape and arrangement of the rostellar hooks. It is worth noting that the only species of the former genus, viz., *C. omalancristrota*, Wedl., and that two out of the three known species of the latter genus, viz., *A. macropeus*, Wedl., and *A. cheilancristrota*, Wdl., occur in birds belonging to the Ciconiiformes (Storks and Cranes).

Type species:—*Clelandia parva*, Jnstn., from the intestine of *Xenorhynchus asiaticus*, Lath.?

Locality:—Jervis Bay, N. S. Wales.

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[1] Fuhrmann, Centrb. f. Bact., Orig., I, XLV, 1908, p. 527; and in Zool. Jahrb., Suppl. Bd., x, Heft 1, 1908, p. 63.

The type slide has been presented to the Australian Museum, Sydney.

My thanks are due to my friend, Mr. S. J. Johnston, B.A., B. Sc., of Sydney University, for handing the specimen over to me.

Reference to Plate VIII.

Clelandia parva, Jnstn.

Explanation of lettering :—*Ap.d.*, apical disc; *c.*, cirrus; *c.s.*, cirrus sac; *e.v.*, excretory vessel; *g.ap.*, genital aperture; *g.h.*, guard of hook; *g.p.*, genital papilla; *h.*, hook; *h.h.*, handle of hook; *l.sp*, large spines at base of cirrus; *ov.*, ovary; *r.*, rostellum; *r.m.c.*, retractor muscles of cirrus; *s.*, sucker; *s.h.*, shaft of hook; *sp.*, spines on cirrus; *t.*, testes; *ut.*, uterus; *v.*, vitelline duct; *v.d.*, vas deferens; *vg.*, vagina; *vit.*, vitelline gland.

Fig. 1. Entire strobila.
,, 2. Scolex.
,, 3. Hook.
,, 4. Young segment with developing genitalia (slightly diagrammatic).
,, 5. Part of a mature segment—cirrus everted.
,, 6. Large spine from base of cirrus.

All figures except figure 4, were drawn using a camera lucida. The ovary is indicated in figs. 4 and 5, by hatched lines.

A COMPLETE ANALYSIS OF SYDNEY WATER.

By SIDNEY G. WALTON, F.C.S.

(Communicated by the Government Analyst, W. M. HAMLET, Esq., F.I.C., F.C.S.)

[*Read before the Royal Society of N. S. Wales, September 1, 1909.*]

So far as I am aware a complete analysis of Sydney water has never been published. For this reason I thought it would be of interest to carry out such an examination and to place the results before the members of this Society.

The water used for the analysis was taken from a tap in the water analysis room of the Government Laboratory, Department of Public Health, and may be considered a fair sample of the average supply.

In order to estimate more accurately those constituents occurring in small amount, large quantities of the water were taken.

As the most important use of the water is for drinking and domestic purposes, it seemed to me advisable to present the various items in the order usually followed in analyses of potable waters, and following these, a complete analysis of the residue. The methods adopted are first described, and the results tabulated at the end of the paper.

Total solids—Four litres of the water were evaporated in a platinum dish and dried at 110° C. to constant weight.

Chlorides—One litre of the water was concentrated and the chlorine determined by titrating with standard silver nitrate using potassium chromate as indicator.

Free and Albuminoid Ammonia—These were estimated in 500 cc. of the water by Wanklyn's process. The amounts

of ammonia given off on distillation, before and after the addition of alkaline permanganate, being determined by nesslerising the distillates.

Nitrites—Ilosvay's napthylamine test was applied, but no nitrites were found.

Nitrates—One litre of the water was concentrated and the nitrate estimated by reducing to ammonia by means of sodium hydrate and aluminium foil, and after distilling off the ammonia, nesslerising the distillate.

Oxygen absorbed in 15 minutes and 4 hours—250 cc. of water were taken for each estimation. Dr. Tidy's modification of Forchammer's method being followed with the exception that the oxidation was carried out at room temperature instead of at 80° F.

Phosphates—As the phosphoric acid was present only in traces, the method described by Dr. Cooksey in this Journal Vol. XLI, p. 171, in which standard tubes are prepared containing known minute quantities of phosphoric acid, was used. For the actual estimation, one litre of the water was evaporated to dryness, and the phosphoric acid estimated after the removal of silica by comparing the ammonio-phospho-molybdate precipitates with those contained in the standard tubes.

Sulphates—Four litres of the water were concentrated and the sulphuric acid precipitated and weighed as barium sulphate.

Temporary hardness—This was estimated by titrating 250 cc. of the water with N/50 sulphuric acid using methyl orange as indicator. A blank experiment was carried out with an equal quantity of distilled water, and the quantity of acid required was deducted from the amount used in the original titration. This method of estimating temporary hardness may be used as the calcium and magnesium pre-

sent are more than sufficient to combine with all the carbonic acid present in the salts in solution.

Permanent hardness—This was found by calculating the sulphates and chlorides of the alkaline earths into their equivalents of calcium carbonate.

Alkalinity—This figure was obtained by direct titration exactly as described for the estimation of temporary hardness.

The metals of the Lead, Tin and Zinc groups—50 litres of the original water were concentrated and evaporated to dryness with hydrochloric acid to render the silica insoluble, taken up with hydrochloric acid, and the filtrate nearly neutralised with ammonia. On treatment with sulphuretted hydrogen and standing, no metallic sulphides separated. To confirm the absence of arsenic, as traces may possibly be volatilised by this treatment, four litres of the original water were concentrated to a small bulk and Gutzeit's test applied, with a negative result. The absence of the metals of the lead and tin groups is thus shown.

The metals of the iron and zinc groups in the solution from 50 litres through which sulphuretted hydydrogen had been passed, were precipitated by the addition of ammonia and ammonium sulphide, the object of adopting this method of precipitation being to facilitate the filtration of the zinc sulphide. The precipitated sulphides were dissolved in dilute hydrochloric acid and after oxidising with a little nitric acid, the iron and aluminium were precipitated as hydrates in the usual manner; the operation being carried out three times to insure the removal of all the zinc. The iron and aluminium precipitate was tested for chromium by fusion with sodium carbonate and potassium nitrate and testing the acetic acid solution with lead acetate. No chromium was found. After combining the filtrates from the iron and aluminium precipitates, the solution was con-

centrated and the metals of the zinc group precipitated as sulphides. Manganese was separated by precipitation as dioxide with bromine water, and weighed as Mn_3O_4, and the zinc was precipitated as carbonate and weighed as oxide. As the amount of zinc was rather high, a week was allowed to elapse, and the zinc re-estimated in a further 50 litres of water, the previous result being confirmed. Neither nickel nor cobalt was present.

Total gases—These were determined by boiling a known volume of water under reduced pressure and measuring the amount of gas given off, allowance being made for temperature and pressure.

Free oxygen—Two methods were used for the estimation of the oxygen, viz. Thresh's[1] and Winkler's,[2] but in neither case did the water show a saturation of more than 60%. This is no doubt due to the action of the iron pipes on the oxygen in the water, which partially removes the oxygen forming oxide of iron.

Free carbonic acid—To one litre of the water was added a little phenol-phthalein solution and the free carbonic acid determined by running in N/50 sodium carbonate until a faint permanent pink colour was produced.

Nitrogen—This was found by subtracting the amounts of the free oxygen and carbonic acid from that of the total gases.

Analysis of the Total Solid Residue.

Silica, Iron, Aluminium, Calcium and Magnesium—Four litres of the water were taken for the estimation of the total amounts of these constituents. The total solid residue was ignited and the silica removed in the customary manner and weighed. The iron and aluminium were pre-

[1] Journ. Chem. Soc., 1890, p. 185. [2] Berichte 21, (1888) 2843.

cipitated together as hydroxides and weighed as oxides,[1] after which the mixed oxides were dissolved in hydrochloric acid, and after diluting and warming with a little potassium iodide, the liberated iodine was determined by titration with standard sodium thiosulphate. The iodine was calculated into its equivalent of ferric oxide, and the amount thus found deducted from the weight of the total oxides, the difference gives the alumina. This method although little used gives very accurate results. The calcium after removal of the zinc and manganese as sulphides was precipitated as oxalate and weighed first as carbonate and afterwards as oxide, while the magnesium was precipitated as magnesium ammonium phosphate and weighed as pyrophosphate. I might mention that the precipitates of silica, calcium, and magnesium were tested spectroscopically for traces of barium or strontium without any being detected.

Sodium and potassium—Four litres of water were taken for this estimation and the usual method for the separation of the calcium and magnesium followed, the metals being weighed as sulphates. It was found, however, that the sulphates contained a small quantity of magnesium. This amount was determined by precipitation as phosphate, calculated to $MgSO_4$, and the weight so obtained deducted from the weight of the total sulphates, leaving the weight of the pure sodium and potassium sulphates. I have always found that the whole of the magnesium is not removed by the usual treatment for the estimation of the alkalies, and in order to obtain accurate results, it is absolutely necessary to determine the quantity remaining with the sulphates of the alkalies. A number of determinations of the alkalies were made and thus a large quantity of the mixed sulphates of the alkalies was available for the estimation of the

[1] A small amount of phosphate was found together with the oxides, this was estimated and allowed for.

potassium. The total filtrates corresponding in all to 21 litres of the original water were combined and after concentration freed from phosphate (by removing as the lime salt) and the potassium precipitated as platino-chloride and weighed as such. The filtrate from the potassium platino-chloride was evaporated to dryness, and the residue tested spectroscopically for lithium without any being detected.

Barium and strontium—50 litres were evaporated to small bulk and after filtering, the residue was tested for barium and strontium by fusing with sodium carbonate, extracting with water, and washing until the filtrate was free from sulphates. The undissolved portion was treated with a little dilute hydrochloric acid, strong hydrochloric acid added, and tested spectroscopically for both metals, with negative results.

Lithium—The filtrate from the 50 litres was made up to 500 cc. and 200 cc., equivalent to 20 litres of the original water, were evaporated almost to dryness, strong hydrochloric acid added, and examined by means of the spectroscope. No trace of lithium could be detected. The absence of lithium was confirmed by testing the alkalies by means of the spectroscope.

Bromine and iodine—The remaining 300 cc. of the above solution—equivalent to 30 litres of the original water—were concentrated until a moist saline mass remained. This was repeatedly extracted with 96% alcohol, and the liquid, after the addition of three drops of 20% potassium hydrate, was evaporated to dryness. The residue thus obtained was treated twice in the same manner, and the final residue after being heated to dull redness was dissolved in water, mixed with chloroform, and a weak solution of chlorine water added drop by drop, shaking well after each addition. No violet colour being given to the chloroform

proved the absence of iodine, but the yellow colour indicating bromine was observed, the quantity of which only amounted to traces. The test for iodine was rendered more delicate by the addition of starch solution to the mixture containing bromine, etc., and subsequently adding drop by drop a solution of N/10 sodium hydrate, thoroughly mixing after each addition, no traces of a blue colour being noticed.

Carbonates—This determination was carried out exactly as described for the estimation of temporary hardness.

PHYSICAL CHARACTERS.

Colour (in two foot tube)	Peaty tint.
Clearness	Fairly clear.
Odour	None.
Reaction to litmus ...	Very slightly alkaline.
Sediment	Traces.

CHEMICAL CHARACTERS.

All the results are expressed in parts per 100,000, with the exception of the gases, which are expressed in cc's. per litre.

	1	2	3	4	Mean
Total solids ...	7·810	7·785	7·803	7·800	7·800
Chlorine	3·025	3·025	...	...	3·025
Free ammonia ...	0·0005	0·0005	...	...	0·0005
Albuminoid ammonia	0·017	0·017	...	...	0·017
Nitrogen as nitrite	Nil	nil	...	...	nil
,, nitrate	0·00239	0·00247	...	...	0·00243
Oxygen absorbed in 15 minutes	0·037	0·037	...	...	0·037
Oxygen absorbed in 4 hours	0·082	0·084	...	...	0·083
Permanent hardness (calculated)	...	...	...	...	1·00
Total hardness (cal.)	...	...	...	...	2·20
Alkalinity (as $CaCO_3$)	1·20	1·20	...	...	1·20

Total gases (sample taken at 24·7° C.)	18·55 cc.	18·98 cc.	18·76 cc.
Free oxygen (Winkler's method)	3·413 ,,	3·407 ,,	3·41 ,,
Free oxygen (Thresh's method)	3·548 ,,	3·552 ,,	3·55 ,,
Free carbonic acid	1·57 ,,	1·57 ,,	1·57 ,,
Nitrogen by difference	...	...	13·71 ,,

ANALYSIS OF TOTAL SOLIDS.

	1	2	3	Mean
Ca	0·259	0·254		0·2565
Mg	0·336	0·3325		0·33425
Zn	0·0327	0·0313		0·0320
Mn	0·0050	0·0050		0·0050
Fe	0·0733	0·0822		0·07775
Al	0·008	0·009		0·0085
Na	1·7444	1·7411	1·7433	1·7429
K	0·1023	...	...	0·1023
CO_3	0·720	0·720		0·720
SO_4	0·6458	0·6478	0·6464	0·6466
Cl	3·025	3·025		3·025
Br	traces	traces		traces
NO_2	nil	nil		nil
NO_3	0·106	0·109		0·1075
PO_4	0·0054	0·0054		0·0054
Si	0·0460	0·0460		0·0460
			Total ions	7·1097

The knowledge obtained from a statement of the total amounts of the ions present in the salts not being sufficient to show how they are combined together, an attempt was made to obtain some information of this character by a treatment of the dried residue with alcohol. In carrying out this treatment four litres of water were evaporated to dryness on a water bath in a platinum dish, the residue repeatedly extracted with cold 40% alcohol, and the ions in both the soluble and insoluble portions estimated.

It was found that 64·12% of the SO_4 together with all the calcium, iron, aluminium, zinc, manganese, phosphoric acid, and 26·93% of the magnesium remained in the insoluble

portion, while all the chlorine, sodium, potassium, and the remainder of the magnesium and sulphuric acid passed into solution.

As 64% of the SO_4 and all the calcium remained in the insoluble portion and as sulphate of magnesium if present would have been removed by this treatment with alcohol, one is driven to the conclusion that the sulphuric acid in the dried residue is present chiefly as calcium sulphate. Again as all the chlorine was in solution, the remainder of the calcium together with the magnesium in the insoluble portion, must have been present as carbonates, with the exception of a small amount present as phosphate.

The most probable constitution of the dried residue is, therefore, as follows:—

	Parts per 100,000.
Sodium chloride	4·4674
Sodium bromide	Trace
Potassium chloride	0·1820
Potassium nitrate	0·0175
Magnesium chloride...	0·3108
Magnesium sulphate	0·2909
Magnesium carbonate	0·6783
Calcium sulphate	0·5878
Calcium phosphate	0·0088
Calcium carbonate	0·1994
Ferrous carbonate	0·1610
Zinc carbonate	0·0614
Manganous carbonate	0·0104
Alumina	0·0162
Silica	0·0950
Organic matter, combined water, etc. (by difference)	0·7131
	7·8000

In conclusion I would like to mention that a partial analysis of Sydney water taken from the Crown Street Reservoir, which was made no less than ten years ago, gave a figure for total solids of 7·3 parts per 100,000, while the chlorine was 3·15. These figures indicate that both the total amount and composition of the residue of the water is extremely constant.

A PLEA FOR THE STUDY OF PHENOLOGICAL PHENOMENA IN AUSTRALIA.

By J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens. Sydney.

[*Read before the Royal Society of N. S. Wales, September 1, 1909.*]

What is Phenology? The word is from the Greek and means the science of "appearances,"—first appearances. The derivation is from φαινειν to show, and few dictionaries contain it. Webster (Supplement) says that the word is a contraction of phenomenology and defines it as "the science which treats of the relations between climate and the phenonema of animal and plant life, such as the migration and breeding of birds, the flowering and fruiting of plants."

It is for a meteorologist to dwell upon the importance of these observations to meteorology. They have been proved to be most useful in a country like Britain, and I believe they will be found to be much more important in Australia. An annual report of phenological observations has appeared for many years past in the Quarterly Journal of the Royal Meteorological Society of London. Instructions to the observers who supply the observational material for the report are contained in "Hints to Meteorological Observers," a book of instructions issued by the Society. The reports give for different districts in the British Isles the date of first flowering of 13 *uncultivated* plants. The society also records observations in regard to animal life.

Mr. E. Mawley, who manages this branch of the Society's work, points out that it is preferable to have a small number of plants for observation and a large number of observers, than a large number of plants and, in consequence, a small

number of observers. A most important matter is uniformity of observation. "The same individual trees and shrubs must be observed every year, and, in the case of herbaceous plants those growing in the same spots." Comparable observations and those only, are of any value.

The work of the first appearances of various birds, insects, etc., can well engage the attention of individual naturalists and naturalists' associations throughout Australia and I dismiss that part of the subject.

I think the work for this continent can only be properly carried out by the Federal Meteorologist, who has Australia studded with observers, and who has the machinery for systematically tabulating results. His local officers in the various States could be put in touch with the Government Botanists in the various States in order that the plants referred to may be accurately determined without which the observations would be valueless. The Federal Meteorologist would obtain valuable data, and the various State Botanists would obtain plants from practically all over their respective States. Thus, science would receive an impetus in two directions.

Notes and Suggestions—(*a*) New South Wales (speaking of my own State only) would require to be subdivided into "regions" for the purpose of this work. The various States have already been subdivided into various divisions for various requirements, and the present work would result in climato-botanical divisions better defined than at present, and these would be of scientific value. Great Britain and Ireland are so divided as I shall show presently. By having as observing stations those of the various meteorological workers, there will be provision for continuity of observations.

(*b*) I have taken the flowering (first expansion of the flower) only, but it is obvious that other observations could

be taken, though not so easily perhaps, *e.g.*, unfolding (flushing) of new leaves, the ripening of the fruits.

(c) If the flowering periods of all important plants, such as timber trees, were systematically recorded by competent observers, the results would have high scientific and practical value. But, as a rule, the number of plants selected would have to be limited, as already hinted.

Practical Value.—In a country like ours, science is greatly helped if she can point out the practical value of a suggested course of action to everyday people. In the present case I will indicate some advantages arising from a study of plant phenology.

(1) "The Australian blacks on the coast are expert fishermen, and Mr. Edward Hill, who possesses much information on the subject, informs me that when the beautiful Waratah or Native Tulip blooms, it is a well known sign to these children of Nature that the sole (a rare fish to be seen in the Sydney market, but of excellent flavour) is very abundant on the sand banks about Botany Bay and in the vicinity of Cook's River, where they may be captured at early dawn, before the ripple comes upon the water. According also to the flowering season of other trees and shrubs, the blacks know the season when the mullet, schnapper, Port Jackson shark (*Cestracion*) or other fish are plentiful in the bays or harbours of the coast."[1]

(2) Their value to bee-keepers is obvious. A good many bee-keepers make phenological records for their own convenience. For instance, Mr. G. H. Smith, of Recherche, Tasmania, showed me his records for many years. I learnt from him that *Eucalyptus obliqua* (Stringybark) and *E. amygdalina* (Peppermint) flower two years and then are three years off, *i.e.*, they flower two years out of every five.

[1] "Acclimatisation" by George Bennett, Melbourne, 1862, pp. 34-5.

E. globulus (Blue Gum) flowers every year and so does *Eucryphia Billardieri* (Pinkwood). Mr. Andrew Murphy, a seed collector in New South Wales told me that *Angophora lanceolata* (Smooth-barked Apple), *Eucalyptus corymbosa* (Bloodwood) and *Eucalyptus tereticornis* var. *dealbata* (a Red Gum), and *E. diversicolor* (the West Australian Karri) all flower every other year. In the Report of the Royal Commission of Enquiry in Forestry (N.S.W.) 1908, at Part ii, p. 607, Mr. William Ager, bee-farmer of Grafton, gives useful information in regard to the flowering period of the native trees, which is the more valuable since we have so few data.

(3) They furnish data for hybridisation observations, whether artificial, or the natural processes which go on in the bush, *e.g.*, such as have been fully proved in regard to the genus Eucalyptus.

(4) They furnish data for ringbarkers, as flowering periods are especially suitable for ringbarking operations.

(5) They furnish data in regard to meteorological conditions, and we want as many useful methods of tackling meteorological questions in this climatically difficult continent, as it is possible to contrive.

(6) They are important in connection with the collection of native seeds—an important Australian industry.

(7) They indicate proper times for Field Naturalists' excursions to visit specific localities.

(8) In fine, the advantage of accustoming people to the systematic making of observations in Natural History cannot be fully ascertained.

Tentative Selection of Plants for Phenological Observations.

In Britain the selection of plants for phenological observations is comparatively easy, firstly, because the vast

majority of plants have vernacular names with which a large number of people are familiar, (indeed in the Reports of the Royal Meteorological Society the plants are referred to by their vernacular names only), and secondly, because an enormous amount of information in regard to the flowering periods of plants was already a matter of common knowledge.

In our extensive State, to say nothing of other Australian States, we shall probably find it desirable to submit lists of three groups of plants, as already hinted, *e.g.*, 1. Coast. 2. Table-lands. 3. Western plains.

Following are some of the practical difficulties in submitting lists of plants in Australia :—

1. Few of our plants have common names.

2. Many names are more or less confusing, *i.e.*, we have more than one Blackbutt, Peppermint, Stringybark, Grey Box, Red Gum, etc. Of such plants as "Tea-trees" and "Everlastings," "Buttercups" and "Goodenias" we have so many as to cause difficulty.

3. Big trees are not suitable as a rule, as they are too high up, and their flowers are often inconspicuous. Trees are much higher in Australia than in Britain, as a general rule.

4. There is readily room for confusion amongst Green and Black Wattles, well as most people know them in a particular district. There is even difficulty with the Christmas bush (*Ceratopetalum gummiferum*) as many people ignore the true flowers and only take note of the coloured calyces.

New South Wales, for the purpose of these observations may be provisionally divided into the following regions :— 1. Coast districts. 2. Table-land and Western slopes. 3. Western plains.

Following are some well-known plants to form a preliminary list to serve as a basis for making selections :—

COAST DISTRICTS.

Eucalyptus paniculata, "Grey Ironbark."
" *microcorys*, "Tallow Wood."
" *longifolia*, "Woolly Buut."
" *resinifera*, "Red Mahogany."
" *corymbosa*, "Bloodwood."
" *maculata*, "Spotted Gum."
" *siderophloia*, "Broad-leaved Ironbark."
Melaleuca styphelioides, "Prickly-leaved Tea-tree,"
Tristania conferta, "Brush Box."
Syncarpia laurifolia, "Turpentine."
Avicennia officinalis, "White Mangrove."
Xylomelum pyriforme, "Native Pear."
Telopea speciosissima, "Waratah."
Actinotus Helianthi, "Flannel Flower."
Boronia serrulata, "Native Rose."
Acacia decurrens normalis, "Green or Black Wattle," the August flowerer.
Acacia decurrens var. *mollis*, "Black or Green Wattle," the November flowerer.
Acacia longifolia, "Sydney Golden Wattle."
Pittosporum undulatum, "Pittosporum."
Bursaria spinosa, "Black Thorn."
Linum marginale, "Native Flax."
Corea speciosa, "A Native Fuchsia."
Melia Azedarach, "White Cedar."
Jacksonia scoparia, "Dogwood."
Dendrobium speciosum, "Rock Lily."
Doryanthes excelsa, "Gymea or Giant Lily."

TABLE-LANDS AND WESTERN SLOPES.

Eucalyptus stellulata, "Black Sally."
" *melliodora*, "Yellow Box."

Eucalyptus sideroxylon, "Fat-cake Ironbark."
Angophora subvelutina, "Apple Tree."
Acacia melanoxylon, "Blackwood."
" *decurrens* var. *dealbata*, "Silver Wattle."
Brachychiton populneum, "Kurrajong."
Banksia marginata, "Honeysuckle."
Bursaria spinosa, "Blackthorn."
Helichrysum bracteatum, "Large Yellow Everlasting."

WESTERN PLAINS.

Acacia salicina, "Coobah."
" *homalophylla*, "Yarran."
" *aneura*, "Mulga."
" *excelsa*, "Ironwood."
" *pendula*, "Myall."
Eucalyptus poplifolia, "Bimbil."
" *melanophloia*, "Silver-leaved Ironbark."
" *ochrophloia*, "Yappunyah."
Ventilago viminalis, "Supple Jack."
Alstonia constricta, "Quinine."
Angophora intermedia var. *melanoxylon*, "Coolabah."
Geijera parviflora, "Wilga."
Grevillea striata, "Beefwood."
Heterodendron oleæfolium,
Canthium oleifolium, "Lemon."
Capparis Mitchelli, "Orange."

When we have made a provisional list of well known plants, we have still to remember that they should be arranged, as far as possible, under the months of flowering, in order that as March comes round, for example, the observer may be on the lookout for specific plants. Now this arrangement, with our irregular flowering seasons, due in part to our continental climate, presents real difficulties. For example, I turn to the herbarium and see *Eucalyptus paniculata*, the Grey Ironbark, collected in flower in eight

months of the year, viz., November to February, and June to September. I should not be surprised if it flowers in other months as well. Of course it does not flower in all these months every year. Again, turning to Tallow Wood, *Eucalyptus microcorys*, I see it flowers in July and from September to December. Some plants as the Native Rose, *Boronia serrulata*, have, however, a very limited flowering period in winter and spring as everyone knows. It is therefore, difficult to construct a floral calendar at this stage, but if I invite attention to the matter and secure the co-operation of a large number of observers, I am sure that in a few years, many of the difficulties of making a list of plants in flower during certain months will disappear.

Bibliography Non-Australian.

A.—Some of the earliest phenological observations are probably those of Gilbert White made at Selborne, Dorset, and those made by William Markwick at Catsfield in Sussex, from the years 1768 to 1793. They form an Appendix to most editions of White's Selborne, where they are placed in parallel colums for comparison.

B.—Enquiry of the Director of the Phenological Office, London, led Mr. R. G. K. Lempfert, Superintendent of Statistics to refer me to the following list of papers in Prof. R. de Courcy Ward's translation (Macmillan) of Hann's "Klimatologie," Vol. I, p. 90. As the work and the translation are so excessively scarce in Australia I quote the bibliograpy here:—

1. S. Günther: Die Phänologie, Münster, 1895.—a short, concise account of researches in this field.

2. O. Drude: Handbuch der Pflanzengeographie, Stuttgart, 1890, pp. 17–48; and Deutschland's Pflanzengeographie, Part i, Stuttgart, 1896; Section v, Die Periodische Entwickelung des Pflanzenlebens im Anschluss and das mitteleuropäische Klima.

3. A. von Oettingen: Phänologie der Dorpater Lignosen. Ein Beitrag zur kritik phänologischer Beobachtungs—und Berechnungsmethoden, Dorpat, 1879.

4. H. Hoffmann: Phänologische Untersuchungen, Giessen, 1887.

5. R. Hult: "Récherches sur les phénomènes périodiques des Plantes," *Nova Acta R. Soc. Sc. Upsala*, Series iii, 1881.

6. E. Ihne: "Phänologische Jahreszeiten," *Potonié Naturw.*, Wochenschrift, x, No. 4, 1895; also, "Karte der Aufblühzeit von *Syringa vulgaris* in Europa," *Bot. Zentrallblatt*, 1885, Vol. xxi, 3 – 5.

7. H. Hoffmann: "Vergleichende phänologische Karte von Mitteleuropa," *Peterm. Mitt.*, xxvii, 1881, 19 – 26.

8. M. Stauq: "Phänologische Karte von Ungarn," *ibid.*, xxviii, 1882, 335 - 339.

9. Very instructive phenological charts were published by A. Angot, in his paper entitled "Résumé des Etudes sur la Marche des Phénomènes de Végétation et de la Migration des Oiseaux pendant les dix Années 1881–90," in the *Ann. Bur. Centr. met. de France*, 1892, I. Mémoires, Paris, 1894, B. 159 – B. 210; also, Angot's great work "Etude sur les Vendanges en France," *ibid.*, 1883, I. Mémoires, Paris, 1885, B. 29 – B. 120, which is important in the study of changes in climate as well. The numerous works of Fritsch, Linsser, etc., bearing earlier dates, cannot be referred to here.

10. The Annual Reports on Phenological observations in the British Isles by E. Mawley, are published in the Quarterly Journal of the Royal Meteorological Society for recent years.

11. See also C. Abbe, in *Maryland Weather Service*, Vol. I, 1899, 267 – 278. Professor Abbe has prepared a report of great value published in 1905, (officially known as No. 5119, Sig. 91) on "The Relations between Climates and Crops," dealing with the physiological and experimental work which has been carried on in laboratories, and also with the results of experience in the open air under natural climatic conditions.

C.—Hoffmann and Ihre of Giessen, Germany (some of their papers are already referred to) wrote "Nature" of 30th March, 1882, giving a list of the "First buds open" and "First fruit ripe" observed at Giessen for many years.

D.—In "Nature" for 13th April, 1882, Mr. J. Edmund Clark has an interesting letter on the same subject, containing useful information.

E.—See also "Instructions for the observation of Phenological phenomena, published by the Council of the Meteorological Society (of London). Price 6d. The instructions are under the heads of Plants, Insects and Birds (also first appearance of Frog-spawn). "Annual Report on the phenological observations." These have been conducted for many years by Mr. Edward Mawley and are published in the Quarterly Journal of the Society. England is divided into sections bearing the letters A, C, E, D, F, I (includes part of Scotland), Scotland H, J, K, and Ireland B, G. There were 106 observers, scattered over the three kingdoms, in 1906. Discussion of the tabulation of the results is most interesting and an abridgment is published.

F.—"A simple method of taking phenological observations" by Edward Mawley. *Trans. Hertfordshire Nat. Hist. Soc.*, vi, 117–122 (1892) is a most valuable paper.

G.—"Phenology" is an item (3800) in the subdivision of subjects (Botany) of the "International Catalogue of Scientific Literature." Specimens of the papers indexed will be found at pp. 515, 516 of the Catalogue (Botany) for 1908 (March).

AUSTRALIAN.

A.—In the Papers and Proceedings of the Royal Society of Tasmania there were recorded, for many years phenological observations in regard to plants (chiefly cultivated exotics) in the Botanic Gardens at Hobart. I do not know

of any other systematic records of the same kind in Australia.

B.—In the unpublished minutes of the Royal Society, N.S.W., 6th October, 1869, it is recorded:—"The Chairman (Edward Bedford, Esq.) called the attention of the meeting to a botanical abstract published in the Proceedings Roy. Soc., Tas., in reference to the time of leafing, flowering and fruiting of a few standard plants in the Royal Society's Gardens, Hobart Town, and suggested that it would be very interesting if a similar abstract could be made in this colony. Mr. Moore undertook to carry out the Chairman's suggestion." 3rd November, 1869, "Mr. Moore intimated to the meeting that he had prepared a paper on the leafing and flowering of shrubs in New South Wales, which he would have much pleasure in putting before the Society at an early meeting." The paper does not appear to have ever been presented.

C.—Haviland, Edwin—Beginning *Proc. Linn. Soc. N.S.W.*, XI, 1049 (1886), Mr. Edwin Haviland has a series of papers entitled "Flowering seasons of Australian plants," being a list of plants in the Sydney district in flower during specified months. There were eight papers in all and the last was in 1888.

D.—Prince, J. E.—"Phenology and rural biology," (*Vict. Nat.*, VIII, 119 (1891). A useful paper, drawing attention to the desirability of encouraging such observations in Victoria.

E.—The statement is made, *ib.*, VIII, 126, "previous phenological reports have been published by the Astronomer's Department" (Mr. Ellery's). On enquiry of the Government Astronomer at Melbourne, Mr. Baracchi writes, under date 20th October, 1908, "So far as I am aware, no Phenological Reports have ever been published by this Observatory."

F.—French, F., Junr.—"Observations on the flowering times and habitats of some Victorian Orchids," (*Vict. Nat.*, XII, 31, 1895). The list comprises 72 species out of the 90 then (1895) recorded for Victoria chiefly in the Melbourne district. A calendar for every month of the year is given showing the orchids observed to have flowered in that month. No years are given, so that the value of the list, for phenological purposes, is not as complete as it otherwise would have been.

G.—Maplestone, C. M.—" Flowering times of Orchids," (*Vict. Nat.*, XII, 82). Mr. Maplestone supplements Mr. French's list by records from a wider range in Victoria. He also gives the months without the years, and thus it is not a guide as to the compartive climatic conditions of any particular year.

H.—Maplestone, C. M.—"Calendars and the indexing of Natural History observations," (*ib.*, XII, 120). In this paper the author explains that he has kept a diary, more or less continuously, since 1861, and has many dated observations concerning Orchids (not published in the paper). The "indexing" refers to his use of Todd's " Index Rerum" a device which he used as an index to his diary.

K.—" Notes on Ecalyptus trees from the point of view of the bee-keeper," by J. H. Maiden, *Agric. Gaz. N.S.W.*, January, 1902.

This compilation is useful only to show how irregular are the flowering periods of some of our trees. Of course " Stringybarks," " Box," etc., include more than one kind of tree, but some of the trees, such as " Yellow Box " and "Tallow Wood " certainly only include one kind.

At my instigation the Under Secretary for Lands, in 1905 and 1908 requested the Foresters to make records of the dates of the trees flowering in their respective districts,

and no doubt in time valuable data will be accumulated from this source (Papers 05/2070 and 80/4192).

APPENDIX.

Mr. H. A. Hunt, Commonwealth Meteorologist, Melbourne, to whom the above paper was submitted, writes as follows concerning it. In regard to the suggestion as to communicating with entomologists and ornithologists, the present paper is entirely preliminary in character, and it is hoped that it may reach observers who deal with the subjects named:—

"Department of Home Affairs, Meteorological Bureau,
Central Office, Melbourne, 23rd August, 1909.

"Dear Mr. Maiden,—It is very kind indeed of you to accord me the privilege of perusing your paper entitled 'A Plea for the Study of Phenological Phenomena in Australia.' I hail with pleasure any effort that will induce the residents of Australia to take this matter up and record systematically the seasonal peculiarities of plant, insect, and bird life. After all, these phenomena are in some respects a truer index of the character of the season, they are the result of a complexity of elements that go to make climate and which results cannot adequately be gauged by the mere tabulation and discussion of figures of the few elements of which we only have instrumental records.

"These are often found contradictory when compared with animal and cereal statistics. The cause of these contradictions is probably due to-factors that we know operate, such as insolation, ionization, etc., for which we have no satisfactory means of acquiring knowledge on an extended scale, and probably also to a number of unknown influences, the character of which will only be brought to light by a systematic study of phenological peculiarities of seasons.

"At the inception of the Commonwealth Meteorological Service I invited our esteemed observers, who now number some 5,000, to include any phenological phenomena with their ordinary

weather notes. The request has not been very encouragingly replied to.

"It must be rememberod that in our country districts, we have no leisured class, and I fear that, from occasional remarks furnished with returns, the recording of fundamental climatological data becomes at times irksome and a tax upon the time of many of our worthy settlers; I have, therefore, hesitated to press for phenological observations.

"It may be that if a tabulation and grouping into districts of plants, insects, and birds, such as you suggest, were supplied to observers, it would stimulate an interest and facilitate a study of the subject This Department has neither the material nor the qualification to classify and locate the plant, insect, and bird life of Australia, but should the work be undertaken, I will gladly distribute such with our usual annual supplies to observers, and plead again with them for co-operation in this interesting and valuable science. To place your views effectively and completely, would it not be advisable to consult with the entomologists and ornithologists of the various States before submitting the question to observers?"

NOTES ON FLOUR-STRENGTH.

By F. B. GUTHRIE, F.I.C., F.C.S., and G. W. NORRIS.

[*Read before the Royal Society of N. S. Wales, October 6, 1909.*]

THE term "strength" as applied to flour refers to that combination of qualities which makes a flour valuable for baking purposes. The problem as to what exactly constitutes flour-strength and whether it is possible to devise some ready means of determining this property without having recourse to the always rather unsatisfactory baking test, is one that has engaged the attention of many workers in different parts of the world for some time and still remains unsolved.

In order to place the problem on a satisfactory basis, the British Home-grown Wheat Committee has arrived at the following definition of flour-strength as "The capacity to make a big well-piled loaf."[1] Prof. Wood[2] further points out that this is a complex of at least two factors, size and shape of loaf. The definition thus stated appears to include all the qualities the presence of which render a flour of good baking quality and to provide a clear statement of the problem presented to us.

It does not, as will be seen, include the power of producing weight of loaf. This property depends upon the power of the flour to absorb water, and although this does not perhaps strictly fall under the definition of strength, we have nevertheless satisfied ourselves that it is a measure of this quality and that those flours which absorb the larger

[1] A. E. Humphries, "The Improvement of English Wheat," Liverpool, 1905, also Humphries and Biffen, Journal Agric. Science, Vol. II, part i., page 1.

[2] T. B. Wood, "The Chemistry of Strength of Wheat Flour," Journ. Agric. Science, Vol II, part ii, page 139.

quantities to produce a dough of a given consistency are invariably those which produce a large well-piled loaf. In using the term "invariably," we mean only to imply that in our own experience flours with high water absorbing power are strong flours. All the new strong-flour varieties of wheat created by the late Mr. Farrer and those which Mr. Sutton his successor, is making, have been chosen on account of their high water absorbing capacity. In other words, while this function is not perhaps a necessary condition of strength it is nevertheless a fairly trustworthy guide, and the water absorbing power of a flour can be regarded as a measure of its strength in much the same way as the amount of carbonic acid in the air of inhabited rooms is a measure of the vitiation of such air.

It has the additional advantage of being a test which is readily applied and capable of fairly accurate determination which cannot be said of the baker's judgment. The art of baking depends so much on the skill of the individual that it is a very difficult thing to get two bakers to agree as to the baking quality of a flour to which they are unaccustomed, and still more difficult to obtain fixed data for the factors, size and shape, upon which accurate comparisons may be based. We consider therefore that it is of importance to determine the causes of the greater power possessed by certain flours of absorbing water, and the following notes embody the results of a few preliminary experiments in this direction, which though not conclusive may nevertheless throw some additional light on the subject.

1. Note on the water absorbing power of different grades of flour.—A sample of coarse middlings as produced by one of the leading millers in Sydney, was taken for the experiment. This product had a water absorbing power of 45·5 quarts per 200 lbs. sack and contained 9·66% gluten. The gluten was yellow, coherent and elastic.

In washing out the dough to obtain the gluten, impurities were noticeable, and it would seem that the usual time (one hour) for standing in dough before washing out is insufficient in the case of coarse products, as the dough during the washing out felt gritty. These middlings were then sifted in order to separate them into finer and coarser grades.

The first portion was retained by a No. 11 dressing silk (112 meshes to the linear inch) and passed through a No. 9 dressing silk (94 meshes to the inch). The second portion was retained by the No. 9 silk and passed through a No. 7 silk (80 meshes to the linear inch). The third portion was that which was retained by the No. 7 silk and passed through a No. 5 silk (64 meshes to the inch). We thus obtained from the original coarse semolina four different grades of varying fineness of division. These behaved towards water as shown in the following table:—

	Water absorption quarts per 200 lbs.	Gluten.
Original coarse semolina	45·5	9·66
A. Portion passing through No. 5 but not through No. 7.	44·0	9·78
B. Portion passing through No. 7 but not through No. 9.	46·6	10·07
C. Portion passing through No. 9 but not through No. 11.	47·0	

The finer portion of the semolina had a higher water absorbing power than the coarser, and the original semolina stands about half way between the finer and coarser portions in this respect. The actual proportions of fine and coarse particles were not determined, so that the exact average could not be calculated.

The effect of fineness of division upon the water absorbing power was even more apparent when the above products were reduced to flour. Each of the portions A, B, and C, and the original coarse semolina was put through the smooth

rolls separately and reduced to flour until it passed through a No. 14 dressing silk (136 meshes to the linear inch). The result was as follows :—

	Water absorption, quarts per 200 lbs.	Gluten.
Original coarse semolina reduced and dressed through No. 14.	47·2	9·34
Portion A (passed through No. 5) reduced and dressed through No. 14.	47·0	9·32
Portion B (passed through No. 7) reduced and dressed through No. 14.	47·4	9·50
Portion C (passed through No. 9) reduced and dressed through No. 14.	47·9	

In the case of portion C. a very small proportion (amounting to ·08% of the whole) could not be got to pass through the No. 14 dressing silk. In other cases the whole was reduced to flour, dressing through No. 14.

It will be seen that here again fineness of division has increased the water absorbing power of the flour, but the peculiarity is noticed that although all the portions examined in the last table were practically of the same fineness, the water absorbing powers were not identical, as might have been expected, but varied with the water absorptive power of the stock from which they were derived.

The above experiments were repeated with a sample of middlings obtained in the Departmental mill from a sample of Fife wheat (a strong flour wheat), the semolina used in the previous experiments being obtained from a soft wheat. The Fife wheat semolina was first separated into three grades.

	Water absorption, quarts per 200 lbs.	Gluten.
A. Portion passing through No. 5 but not through No. 7.	48·9	12·06
B. Portion passing through No. 7 but not through No. 9.	49·3	12·21
C. Portion passing through No. 9 but not through No. 11.	50·8	11·74

On reducing these several products separately to flour, and dressing through a No. 14 silk, the following results were obtained:—

	Water absorption, quarts per 200 lbs.	Gluten.
Portion A (passed through No. 5) reduced and dressed through No. 14.	51·7	11·63
Portion B (passed through No. 7) reduced and dressed through No. 14.	52·0	11·48
Portion C (passed through No. 9) reduced and dressed through No. 14.	55·0	11·77

In this case the peculiarity noticed in the previous experiment is even more strikingly exemplified. If the water absorbing powers of the different grades of semolina are alone considered, it would appear that fineness of division is the determining factor, but on reducing these different grades to flour of a uniform grade the rather curious fact is to be noted that although further reduction in the size of the particles increases the water absorbing power, the flour derived from the finer and more absorptive grades of middlings is more water-absorptive than that obtained from the coarser grades.

In the case of the soft wheat this is not very striking, but in the case of the Fife wheat the gradation is quite strongly marked. The cause of this is so far unexplained.

2. The effect of blending different wheats on the water absorbing power of the resulting flour.—Two wheat mixtures were taken, one a mixture of the following soft wheats, Hudson's Early Purple Straw, Steinwedel and Federation, the other a strong-flour wheat mixture of Manitoba, Bobs and Comeback. These wheats when reduced had the following water absorbing powers and gluten contents.

	Water absorption, quarts per 200 lbs.	Gluten.
Sample A (soft grain)	45·0	8·2
Sample B (hard grain)	50·8	13·8

These wheats were blended in three different proportions and the blends milled separately, when the following results were obtained :—

	Water absorption, quarts per 200 lbs.	Calculated.	Gluten.
Original Sample A (soft) ...	45·0	...	8·2
Original Sample B (hard) ...	50·8	...	13·4
Blend 1 ($\frac{3}{4}$ A and $\frac{1}{4}$ B) ...	46·2	(46·7)	9·55
Blend 2 ($\frac{1}{2}$ A and $\frac{1}{2}$ B) ...	49·1	(47·9)	11·55
Blend 3 ($\frac{1}{4}$ A and $\frac{3}{4}$ B) ...	50·8	(49·2)	11·9

It is to be noticed that the water absorbing power of the blend is on the whole somewhat higher than that calculated and in this case the most favourable blend appears to be an equal mixture of the two. The blend formed by mixing $\frac{3}{4}$ of the strong-flour wheats with $\frac{1}{4}$ of weak-flour wheats has exactly the same water absorbing power as the original strong flour wheat.

3. Effect of mixing different grades of flour upon the water absorbing power of the resulting blend.—Two samples of flour, one a fairly strong and the other a rather weak flour, were taken in order to ascertain what effect blending would have upon their water absorbing power.

The weak flour A had a water absorbing capacity of 48·9 quarts per 200 lbs. flour, the strong flour B a water absorbing capacity of 52·6. They were blended together in different proportions, the blending being done by thoroughly mixing them in a flour-sifter provided with revolving arms, and repeatedly passing them through a dressing silk (No. 14) 136 meshes to the linear inch. The following table gives the rather peculiar result :—

	Water absorption, quarts per 200 lbs.	Duplicate.	Calculated.
Original sample A (weak flour)	48·9	...	...
Original sample B (strong flour)	52·6	...	...
Blend No. 1 ($\frac{3}{4}$ A and $\frac{1}{4}$ B)	51·0	50·0	(49·7)
Blend No. 2 ($\frac{1}{2}$ A and $\frac{1}{2}$ B)	51·7	52·0	(50·7)
Blend No. 3 ($\frac{1}{4}$ A and $\frac{3}{4}$ B)	53·6	53·7	(51·6)

This experiment was repeated with the two flours obtained in the previous wheat blending experiment:—

	Water absorption, quarts per 200 lbs.	Calculated.	Gluten.
Original sample A (weak flour)	45·0	...	8·2
Original sample B (strong flour)	50·8	...	13·4
Blend No. 1 (¾ A and ¼ B)	46·5	(46·7)	9·6
Blend No. 2 (½ A and ½ B)	48·9	(47·9)	11·4
Blend No. 3 (¼ A and ¾ B)	51·8	(49·2)	12·1

The last experiment was repeated on flour obtained by milling single varieties of wheat in order to avoid using a blend of different wheats which has been shown to affect the water-absorbing power of the resulting flour.

The wheats taken were A a sample of Velvet Ear from New Zealand, a weak-flour wheat deficient in gluten, and B a sample of Comeback, one of Mr. Farrer's strong-flour creations. These wheats were converted separately to flour and gave the following results on blending:—

	Water absorption quarts per 200 lbs. sack.	Calculated.
A (Velvet Ear)	48·0	
B (Comeback)	53·6	
Blend No. 1 (¾ A and ¼ B) ...	50·2	49·4
Blend No. 2 (½ A and ½ B) ...	51·8	50·8
Blend No. 3 (¼ A and ¾ B) ...	53·6	52·2

In all these cases the water absorbing power of the blend of ¾ strong and ¼ weak flour was not only considerably higher than the calculated, but as high as or even distinctly higher than that of the original strong flour. The strong flours had a slightly yellowish tinge and the weak flours more nearly white. The increase of yellow in the blend both of wheat and flour increased apparently regularly with the increased proportion of strong flour, but the peculiarity was noticed that the flour blends were of a better colour than the wheat blends, even when the flours were produced in the Departmental mill. It would therefore

appear more profitable to the baker to blend his flours than to use flour of one quality from a mixture of wheats, and that the addition of a small proportion of weak flour to his strong flour, so far from reducing the water absorbing power of the latter, actually increases it.

In order to judge of the relative baking nature of these flours and blends the flours obtained in the last experiment were baked into small loaves (160 grammes flour being taken in each instance) and the volume of each loaf calculated from its displacement of wheat. This amount is given in cubic centimetres:—

Loaf from 160 grammes.	Volume.
A (Velvet Ear)	542·6 cubic centimetres
B (Comeback)	579·3 ,,
Blend No. 1 ($\frac{3}{4}$ A and $\frac{1}{4}$ B) ...	552·7 ,,
Blend No. 2 ($\frac{1}{2}$ A and $\frac{1}{2}$ B) ...	558·7 ,,
Blend No. 3 ($\frac{1}{4}$ A and $\frac{3}{4}$ B) ...	583·0 ,,

Not only were the volumes of the strong-flour loaves larger, but the admixture of a small proportion of the weak flour gave a loaf of larger volume than was obtained from the strong-flour used alone. The loaves from B and from blend No. 3 were beautifully even in texture and in shape, the loaves from the weak flour and from the blends in which weak flour predominated being of inferior texture and exceedingly irregular in shape, which latter peculiarity may be seen from the attached outlines which represent the contour of the loaves cut through the centre.

Outlines of loaves obtained in the baking tests. The loaves have been cut through the centres, figures are one-fourth actual size.

ON SOME BUILDING AND ORNAMENTAL STONES OF NEW SOUTH WALES.

By R. T. BAKER, F.L.S., Curator Technological Museum, and JAMES NANGLE, F.R.A.S., Lecturer in Architecture, Technical College, Sydney.

[*Read before the Royal Society of N. S. Wales, October 6, 1909.*]

OF necessity our building stones have occupied a foremost place in the State's architecture since the landing of Captain Phillip at Sydney Cove in 1788, although no paper so far appears to have been read before the Society on the subject. Rev. Tenison-Woods has two papers on the Sandstones—Hawkesbury 1882 and Desert 1888, but these deal exclusively with the geological side of these materials, whilst in this paper it is the economics or applied science alone that is more especially touched upon.

From the exigences of the "first landing" it can readily be understood that building material was the first desideratum of that time, although of course timber was most probably the first to be laid under tribute, the bush necessarily being required to be cleared, but with a plentiful supply of freestone at hand it was not long before the splendid Hawkesbury Sandstone was freely utilised, and from thence onward has filled an important place in our architectural structures. There is one notable survival of those times, viz., the Macquarie obelisk, built in 1818 from Sydney sandstone, and bearing the following inscription:—

"This obelisk was erected in Macquarie Place, A.D. 1818, to record that all the public roads leading to the interior of the colony are measured from it.

L. MACQUARIE, Esq.. Governor."

It furnishes a good instance of how an idea originating to serve one special purpose sometimes does duty for that of another, for being originally erected to definitely fix a starting point for all distances in the colony, yet to-day it serves to illustrate the durability of well selected stones, for although exposed in this case for nearly a century, it shows scarcely any signs of weathering.

That attention was given rather early in the State's existence to stones other than sandstone is proved by the following reference in Mitchell's expeditions into Australia, Vol. II, p. 318, published in 1838:

"Near the Wollondilly, a few miles from Towrang, a quarry of crystalline variegated marble, has been recently wrought to a considerable extent. and marble chimney pieces, tables, etc., now ornament most good houses at Sydney. This marble occurs in blocks over greenstone, and has hitherto been found only in that spot."

In passing we may say that so far we have not been able to locate this particular spot, nor have we seen any of the specimens made from the material. Since then our lithic building material has gradually become still better known and the industry appears now to be firmly established. Sydney can well be proud of its noble buildings constructed of local material, and to us it appears that the time has arrived when our building and ornamental stones should be architecturally classed and tested for the future reference of those interested in the subject. Few results in this direction appear to have been published, although Professor Warren has tested some specimens we believe, whilst in Professor Liversidge's book, "Minerals of New South Wales," and also in the Mines Department Reports, lists of localities and other data are given.

In this paper is given the first fairly exhaustive series of tests yet carried out in Australia on building stones, and in

view of the modern machinery that has been installed by the trade for quarrying, cutting, and polishing, and the utilisation of the output by the architectural world of the Commonwealth, it is hoped these results will be of assistance to those working in this sphere of applied science. There can be no question that there is a great future before the whole industry, for the value of the imported article in 1908 alone amounted to over £20,000.

In the matter of quality, durability and colour, the majority of our stones must be ranked as first class. The grey granites of Uralla, Trial Bay, and many others are certainly equal in hardness and colour to the best Scottish, whilst our marbles as shown by our tests are much harder than those imported, and at the same time possess a remarkable variety of colours.

The two most important qualities necessary in building stones are:—1. Colour, 2. Durability.

1. Colour.—Colour is an all important feature in the selection, for when any particular stone is mentioned it is almost certain to be asked what is the colour?—a character that is almost invariably due to the presence of certain minerals. Our granites vary in degree of colour and may be classified generally as red and grey, both fine and coarse grained, and when the presence of a particular mineral is sufficiently large to retain its distinctive colour it is then applied to the whole, as for instance, Tenterfield, Barren Jack, Mudgee and Gabo red granites where the flesh coloured felspar crystals predominate. Our grey granites present many shades of these tints and give a splendid choice to the architect to satisfy his ideals of harmony or contrast.

The great advantage of granite over marble is, that its colour is practically constant from the quarry to its final disintegration, and is never subject or liable to dis-

colouration from cement or other foreign substances, or from climatic conditions, for the granites of the Post Office colonnade show no sign of changing colour after a thirty years' exposure, and the Montague Island bases of the columns, with their labradorite crystals are resisting the inroads of climatic conditions very satisfactorily. Such constancy of colour however, does not hold with sedimentary and metamorphosed rocks, for sandstones are generally a darker shade when first quarried and become lighter in colour, or *vice versa* when exposed. For instance the mountain sandstone is very soft when first quarried but on exposure hardens and changes to almost white; and even the Pyrmont sandstone upon exposure changes to a very pleasing straw colour. In the fire test (*infra*) Sydney sandstone changes to light brick red, due no doubt to the presence of oxide of iron, a constituent that in all probability gives the dark brown colour to the Ravensfield sandstone.

In the case of marbles colour plays a very important part and requires special care and attention, for the market value of a stone is often influenced by its colour without regard to its strength and durability, and now that so many varieties are being submitted to the architectural world of New South Wales, it is hoped that a gratifying, artistic and harmonious combination of stone colours will result. We have used the word harmonious because a building of many colours is not art, but at the same time a too sombre colour is not desirable in this climate of blue sky, for to our taste the new railway station in its internal mural colours is rather inclined to the dull side of things.

The colour of a sandstone rock when freshly quarried may be pale coloured or almost perfectly white, but after a short time of exposure the colour may change to a buff or the stone may be streaked with irregular patches of ferrous oxide. Such discoloration depends chiefly upon the

presence of impurities within the stone itself. The yellow of many limestones is often due to the presence of finely disseminated iron sulphide. If stone contain either the sulphide or the carbonate of iron, discoloration is a natural consequence of exposure to the atmosphere, and such stone often weathers buff after a few years exposure. The oxides of iron are more stable compounds than the sulphide or carbonate, and are less liable to alteration.

Discoloration in the face of a marble wall may be due to impurities in the mortar, cement, or brick used in the construction, which are brought to the surface through capillary attraction. The iron stains in marble in a wall are probably also due to the ferrous oxide in the mortar, cement or brick used in the construction rather than in the marble itself, and are brought to the surface through capillary attraction. A preventative against ferrous iron in the brick or mortar of the back wall coming to the surface is a coat of asphalt between the back wall and the stone facing, or better still the selection of lime cement, and brick in which it is certain that ferrous iron is not present.

This question of discoloration of marble requires more attention than perhaps has been bestowed upon it in the past, or otherwise a public prejudice may set in against our beautiful stones. Many of our marbles, such as red and blue Borenore, Kempsey and Springhill, are being extensively used now on shop fronts in Sydney, Newcastle and other towns and it must be admitted with good effect, but will it retain its good name under present treatment? For instance, is there anything wrong with the polish when the stone does not seem to retain its lustre any length of time? Is care taken with the backing in order that no foreign substance is likely to cause discoloration by capillary attraction? These two defects are beginning to become evident in a few of the marbles now adorning business premises in Sydney, and are only mentioned here

so that action may be taken in future to preserve the good name of our marbles, for the condition of things in connection with the Post Office lamp pedestals is almost world famed, and, unjustly, this inferior foreign material has been assigned a New South Wales origin, when such is not the case.

Fortunately the smoke, fog and damp of the northern climes is mostly absent in this sunny south, so that much greater liberties can be taken with our stones in the matter of climatic exposure, and so less fear is given to loss of, or injury to colour by these adverse conditions, as the original colour will not suffer so much from external causes alone. One great advantage under which our architects work in this country is that climatic conditions do not enter so largely in constructional calculations as obtains in some of the countries of higher latitudes, for we have a dry climate such as also obtains in Rome and Egypt, where we know that well preserved specimens of the architect's art have been handed down through long ages, their preservation being due to the arid state of the atmosphere. Thus our architects have the opportunity of handing down their ideals of beauty, cut in stone, to the admiration of coming generations.

One great advantage enjoyed by our architects in working in what may be regarded as a comparatively equable climate, is that certain factors which must enter very largely into the use of stone in colder climates are absent, there are no extremes of heat and cold—factors which must be studied when using stone where such occur, and such terms as "an equal expansion" and "construction" rarely give serious consideration here. When used for internal decoration no heed need be given to atmospheric conditions as the colour will if not injured by defective backing material almost invariably remain permanent, and a selection of stone, then, becomes merely a question of taste.

New South Wales Rocks arranged on a Colour Basis:

1. Igneous Rocks.

Granites.

(a) *Red.*

Albury
Barren Jack
Braidwood
Bungendore
Bungonia
Broula Hills (Cowra)
Carrick
Cooma
Cowra
Gabo Island
Grenfell
Inverell
Jerangle
Jindabyne
Maffra
Mudgee
Mulloon Creek
Murrumbateman
Rylstone
Tarago
Tarana
Trial Bay
Wombeyan

(b) *Grey.*

Adelong
Albury
Arnprior
Bathurst
Braidwood
Breadalbane
Bredbo
Bungendore
Burrowa
Collingwood
Cooma
Cowra
Goulburn
Gunning
Harden
Inverell
Jerangle
Lake Bathurst
Montague Island
Moruya
Oberon
Tenterfield
Trial Bay
Tumut
Uralla
Yass
Young

Various Colours.

Gneiss.

Bungendore (yellowish) Pomeroy (grey) Cooma (grey)

Trachyte.

Bowral (grey) Canoblas (yellow)

PORPHYRY—Various Colours.

Bredbo	Hall
Burrowa	Michelago
Canberra	Murrumbateman
Cowra	Uriarra
Currawong	Yass
Goulburn	

DIORITE.

Bumbaldry	Jerangle	Tumut
Goulburn	Tarago	Wee Jasper

BASALT.

Dundas Inverell Jerangle Kiama Orange

DOLERITE.

Prospect

2. NEW SOUTH WALES MARBLES ARRANGED ON A COLOUR BASIS.

1. COLOURED MARBLES (Red to Yellow.)

(a) *Variegated.*

Bingara
Bucheroo
Bumbaldry
Burrowa
Caleula
Carroll
Coolalie
Fernbrook
Jeir
Limekilns
Marulan
Michelago
Molong
Mudgee
Parks
Portland
Warialda

(b) *Crinoidal.*

Kempsey
Michelago
Nemingha

(c) *Brecciated.*

Attunga
Bingara
Red Borenore
Fernbrook

2. GREEN MARBLES.

Binalong
Queanbeyan

3. BLACK MARBLES.

(a) *Black.*

Taraga
Windellama
Wee Jasper

(b) *Black and White.*

Orange
Rylstone
Springhill

(c) *Crinoidal.*

Bibbenluke

Gresford

Rockley

4. White and Statuary Marble.

Abercrombie Caves

Brundle Creek

Caloola

Coolalie

Cow Flat

Gilmore

Havilah

Michelago

Parkes

Wombeyan Caves

5. Blue and Grey Marbles.

(a) *Variegated.*

Bungonia

Cowra

Cudal

Michelago

(b) *Brecciated.*

Blue Borenore

6. Laminated Marbles.

Adelong (Gilmore)

Gilmore

Norongo

Queanbeyan

Tarrabandra

7. Onyx Marble.

Moruya

8. Unclassified.

Bungendore

Cooma

Gundagai

Jenolan Caves

Moonbi

Tumut

Walli

Yarrangobilly

2. Durability.—It is perhaps too early in the life of our stones to give data concerning their durability, but our granites, trachytes, and sandstones so far appear to give satisfaction in this direction, although in a few isolated cases sandstones have shown signs of weathering or disintegration. This latter defect is perhaps due to a want of a proper selection of stone, for it appears the time has come when a stone expert is necessary, just as there is in commerce a wool or timber expert, one who should be well versed in petrology and make the study of this science his profession, and whose business should consist of passing all stone before it is placed in a building. There certainly must be something in the art of selecting say a sandstone,

as for instance the stone of the Macquarie obelisk, which has now stood all weathers for nearly 100 years and is as sound as the day it was built.

This fretting of our sandstone in certain situations has received some attention from the Colonial Architect Mr. Vernon and Mr. H. C. Kent, who are of opinion that it is due to a perishing of the cementing medium of the quartz particles, a kind of dry rot, and which only appears to occur when the stone is not exposed to the moisture of the atmosphere. In the absence of practically any age data concerning the durability of our stones, the next best thing has been undertaken, viz:—crushing and fire and water tests.

Fire Tests.—As far as we have been able to ascertain, no data exist as to the refractoriness of our building stones, so that the data in this connection given below may be of value to architects and others interested in this feature of them. The samples tested were necessarily small as muffles were not available to take larger samples. The typical rocks were only taken and the results, few as they are, are comparative. Two methods were available for obtaining the temperature of muffle furnaces, viz.: Siemen's pyrometer and Pitkin White's Thermo-electric pyrometer. The former was found to work very satisfactorily so was used for all demonstrations. The samples subjected to this particular test were sandstones, marbles, trachytes, and granites, and the data speak for themselves. It may, however, be stated in passing, that the sandstones came best through the different fire and water tests.

Crushing Strengths.—These were carried out at the Technical College by Mr. James Nangle with the 100 ton crushing machine, and the most interesting feature of the series is the remarkable breaking resistance of some of the marbles which in the case of the Caleula varieties

exceeded in strength that of all the granites and trachytes, and this compact texture of our marbles is also well maintained in many of the other samples tested.

Table showing the Crushing Strength of some well known Australian Building Stones.

No.	Kind.	Locality where obtained.	Size of specimen in inches	Strength in tons per sq. in.	Rate of load applied in tons per minute.
1	Sandstone	Belmore	3·06 × 3 06 × 3·07	7·13	11·13
2	,,	,,	3·08 × 3·08 × 3·06	5·25	
3	,,	,,	3·05 × 3·05 × 3·08	6·46	10·02
1	Sandstone	Bundanoon	3·01 × 3·03 × 2·99	2·50	2·53
2	,,	,,	3 00 × 2·99 × 3·00	2·63	2·28
3	,,	,,	3 07 × 3·04 × 3·06	2·47	2·30
1	Sandstone	Pyrmont	3 00 × 3·00 × 3·04	2·17	2·79
2	,,	,,	3·02 × 2·93 × 3·00	2·52	2·47
3	,,	,,	3 00 × 2·98 × 3·06	2·57	2·55
1	Sandstone	Ravensfield	3·04 × 3·04 × 3·06	4·72	3·63
2	,,	,,	3·04 × 3·02 × 3·04	4·85	4·45
1	Sandstone	Willoughby	3·04 × 3·12 × 3·07	1·83	2·17
2	,,	,,	3·02 × 3 08 × 3·05	1·59	3·70
3	,,	,,	3·10 × 3 04 × 3·06	1·73	2·32
1	Trachyte	Bowral	3·04 × 3·05 × 3·10	7·44	9·85
2	,,	,,	3·05 × 3·01 × 3·04	8·06	8·23
3	,,	,,	3·00 × 3·04 × 3·05	9·37	7·77
1	Granite	Barren Jack	3·05 × 3·05 × 3·05	7·61	8·84
2	,,	,,	3·08 × 3 07 × 3·03	5·59	7·55
3	,,	,,	3 08 × 3·09 × 3·09	7·41	11·73
1	Granite	Gabo Island	3·09 × 3·12 × 3·12	6·80	13·12
2	,,	,,	3·07 × 3·10 × 3·13	6·67	15·86
3	,,	,,	3·08 × 3·11 × 3·12	7·83	7·00
1	Granite	Moruya	3·05 × 2·96 × 3·05	5·93	
2	,,	,,	3·08 × 3·06 × 3·05	6·75	15·91
3	,,	,,	3·05 × 2·99 × 3·07	6·28	19·05
2	Granite	Tenterfield	2·77 × 2·77 × 2·78	5·21	13·33
3	,,	,,	3·04 × 3·00 × 3·09	6·02	
1	Marble	Attunga	3 05 × 3·06 × 3·06	5·38	
2	,,	,,	2·99 × 3·01 × 3·06	4·34	
3	,,	,,	3·03 × 3·02 × 3·06	3·84	2·50
1	Marble	Warialda	3·04 × 3·08 × 3·06	3·18	3·72
2	,,	,,	3·04 × 3·12 × 3·09	1·77	5·61
3	,,	,,	3·03 × 3·07 × 3·04	1·07	5·00

Table showing the Crushing Strength of some well known Australian Building Stones—*continued.*

No.	Kind.	Locality where obtained.	Size of specimen in inches.	Strength in tons per sq. in.	Rate of load applied in tons per minute.
1	Marble	Caleula	3·00 x 3 03 x 3·01	9·44	6·60
2	,,	,,	3·02 x 3·03 x 3·03	7·09	8·11
3	,,	,,	2·98 x 3 03 x 3·03	6·09	10·99
1	Marble	Kempsey	3·02 x 3·02 x 3·03	6·69	8·72
2	,,	,,	3·01 x 3·02 x 3·01	6·66	7·57
3	,,	,,	3·01 x 3·02 x 3·02	7·99	14·54
1	Marble	Fernbrook	3·02 x 3 03 x 3·02	7·28	11·11
3	,,	,,	3·02 x 3·03 x 3·00	8·31	12·68
1	Marble	Borenore	3 01 x 3 01 x 2·97	5·46	7·07
2	,,	,,	3·00 x 2·97 x 3·01	5·16	4·18
3	,,	,,	3·00 x 2·97 x 3·02	5 92	2·63
2	,,	Fernbrook	3·01 x 3·03 x 3·00	4·66	2·68
1	,,	Springhill	3·03 x 3·01 x 3 00	7·47	2·52

THE EFFECT OF HEAT ON NEW SOUTH WALES BUILDING STONES.

No,	Rock Treated.	Temp. of Furnace °C.	Time in Furnace Minutes.	How Treated and Remarks.
1	Pyrmont Sandstone	750	15	Plunged suddenly into cold water at 12° C. Practically no effect. Edges unchipped, colour considerably deepened, otherwise uninjured.
2	,, ,,	746	20	Cooled slowly in air, colour changed from straw yellow to pale pink, otherwise uninjured.
3	,, ,,	·800	15	Half submerged in cold water. A crack at once appeared at right angles to the surface of water.
4	,, ,,	760	45	Heated gradually during 45 minutes and half submerged in cold water; after short interval cooled under tap; uninjured.
5	Bundanoon Sandstone	751	25	Half submerged in cold water; afterwards cooled beneath tap.

Effect of Heat on New South Wales Building Stones—*continued.*

No.	Rock Treated.	Temp. of Furnace ° C.	Time in Furnace Minutes.	How Treated and Remarks.
5	Bundanoon Sandstone	751	25	Change in colour very slight, faint crack appeared across the cube at right angles to surface of water. No change in texture.
6	„ „	785	20	Plunged suddenly into cold water at 11° C. Deepening of colour hardly perceptible, small piece flaked off from one edge. No change in character.
7	„ „	792	15	Plunged suddenly into cold water, entirely unaffected, edges unchipped.
8	„ „	822	20	Half submerged in cold water. A prominent crack and one very small crack at once appeared at right angles to the surface of the water. No change in character.
9	Bundanoon Sandstone	674	30	The specimen was placed in the furnace which was gradually heated for half an hour, when the temperature was ascertained and the specimen taken out and a spray of cold water played on it till cooled. The result was nil.
10	„ „	674	30	Similar treatment to No. 9, with almost similar results, only a slight breakage on one edge.
11	Willoughby Sandstone	674	30	A coarser grained stone than No. 9, changed slightly in colour, otherwise similar results to No. 9.
12	„ „	674	30	Ditto ditto
13	Bowral Trachyte	843	15	Sudd[illegible] plunged into cold wat[illegible], badly cracked in several places, colour changed to dark brown.

Effect of Heat on New South Wales Building Stones—*continued.*

No.	Rock Treated.	Temp. of Furnace ° C.	Time in Furnace Minutes	How Treated and Remarks.
14	Bowral Trachyte	767	20	Semi-submerged in cold water; afterwards cooled off beneath tap. Badly cracked along edge on portion submerged, colour changed to deep brown.
15	Moruya Granite	806	15	Seven minutes after entry into furnace badly cracked in several places. On removal quite shattered into small fragments
16	„ „	806	15	Ten minutes after entry into furnace this specimen showed number of small cracks. On removal plunged into cold water, immediately flew to pieces with report.
17	Barren Jack Granite	830	15	After 3 minutes cracked across diagonally. Removed after 15 minutes and allowed to cool slowly; cracked in several places but not shattered, otherwise stood the test well.
18	„ „	784	45	Allowed to heat gradually in furnace, taken out unaltered and plunged into cold water, several prominent cracks at once appeared, otherwise stood the test well.
19	Gabo Island Granite	783	35	The cube was placed in cold furnace and heated gradually. At 717° a small crack appeared. After removal, cube very badly cracked in many places—almost shattered.
20	„ „	544	20	Heated gradually and plunged suddenly into cold water. Almost unaffected, several small cracks can be seen on close examination.
21	Tenterfield Granite	701	30	Heated gradually, at 701° it was noticed that the cube was cracked and on removal it crumbled into fragments.

Effect of Heat on New South Wales Building Stones—*continued.*

No.	Rock Treated.	Temp. of Furnace ° C.	Time in Furnace Minutes	How Treated and Remarks.
22	Tenterfield Granite	544	20	Heated gradually and plunged suddenly into cold water. Almost unaffected, on close examination several small cracks could be seen to be developed.
23	Nemingha Marble	542	25	Heated gradually and cooled slowly in air. Calcination not started and rock unaltered.
24	,, ,,	719	25	This specimen was placed in the hot furnace, but owing to trouble with the furnace, the temperature became much reduced, but was afterwards raised again. The specimen on removal was plunged into cold water, cracks appeared in several places, but the calcination was only slight. Came through the test fairly well.
25	Warialda Marble	744	35	Heated gradually and cooled in air. Specimen ruined.
26	Attunga Marble	758	40	Heated gradually and cooled in air. Specimen broken into pieces.
27	Warialda Marble	808	10	Placed in hot furnace. Cracked slightly on removal. Plunged into cold water, broke in two pieces. Specimen ruined.
28	Attunga Marble	802	10	Placed in hot furnace. Cracked slightly on removal. Plunged into cold water, badly cracked in several places. Specimen quite disfigured.
29	Fernbrook Marble	695	30	The furnace was gradually heated up to this temperature when the specimen was taken out and a spray of cold water played upon it. The original colour was quite destroyed although the edges remained intact.

Effect of Heat on New South Wales Building Stones—*continued.*

No.	Rock Treated.	Temp. of Furnace °C	Time in Furnace Minutes	How Treated and Remarks.
30	Fernbrook Marble	695	30	The furnace was gradually heated up to this temperature when the specimen was taken out and a spray of cold water played upon it. The original colour was quite destroyed although the edges remained intact but calcined.
31	Caleula Marble	695	30	Ditto, ditto, ditto, colour not so obliterated as 29 and 30, but more edges were calcined.
32	,, ,,	695	30	Ditto, ditto, but edges still further calcined.
33	Springhill Marble	656	45	Similar condition to No. 35, but very much less affected, original structure still retained and much of the colour.
34	,, ,,	656	45	Ditto, ditto
35	Windellama Marble	656	45	The furnace was gradually heated up to this temperature during this time, when the specimen was taken out and a spray of cold water played on it. The original colour was quite destroyed on the surface and specimen cracked.
36	,, ,,	656	45	Similar conditions to 35, but after half an hour the specimen burst with a loud report into four pieces.
37 and 38	Blue Borenore Marble	648	30	Placed in a furnace heated to this temperature and left for half an hour. Fared badly, for when the stream of cold water was played upon them they cracked in several directions, lost original colour and became almost calcined.

All the above specimens are now placed permanently in the Technological Museum, Sydney.

The Yass-Canberra District.

As the final selection of a Commonwealth Capital site will probably be made in the southern tableland of this State, a special flying lithic survey was made in order to collect information regarding the resources of this district in building and ornamental stones. The results were beyond expectations, and prove conclusively that in this particular architectural material it is especially rich, as shown below. If such results could be obtained in so short a time working over one area of this State, it certainly demonstrates that in others, where indications are already known, that in the matter of building and ornamental stones New South Wales must be remarkably wealthy. The following are localities from which the respective stones were obtained, full descriptions of which will be given in "Building and Ornamental Stones," Part II, by R. T. Baker. Technological Museum.

Red Granite.

Barren Jack	Jerangle
Braidwood	Maffra, near Cooma
Bungendore	Mulloon Creek, near Bungendore
Bungonia	Murrumbateman
Cooma	Tarago

Grey Granite.

Adelong	Collingwood near Gunning
Arnprior	Cooma
Braidwood	Gunning
Bredbo	Harden
Breadalbane	Jerangle
Bungendore	Tumut

Gneiss.

Bungendore	Cooma	Pomeroy near Goulburn

PORPHYRY.

Bredbo	Currawang	Murrumbateman
Burrowa	Hall	Uriarra
Canberra	Michelago	Yass

DIORITE.

Goulburn	Jerangle	Tarago	Tumut	Wee Jasper

BASALT.

Jerangle

MARBLE.

Binalong	Coolalie	Jeir	Tarrabandra
Brundle Creek	Cooma	Michelago	Wee Jasper
Bungendore	Goulburn	Norongo	Windellama
Burrowa	Gilmore	Queanbeyan	Yass

SLATE.

Bungendore	Gundagai	Taralga
Cooma	Jerrawa	Towrang
	Queanbeyan	

SERPENTINE.

Gundagai	Tarrabanda	Tumut

QUARTZITE.

Burrowa	Queanbeyan	Tarago	Tarrabandra	Uriarra

SANDSTONE.

Barbers Creek	Canberra	Marulan
Braidwood	Galong	Mundoonan
Bundanoon	Grong Grong	Yass

THE NATURE OF THE LARGE IONS IN THE AIR.

By J. A. POLLOCK, D. Sc., etc.
Professor of Physics in the University of Sydney.

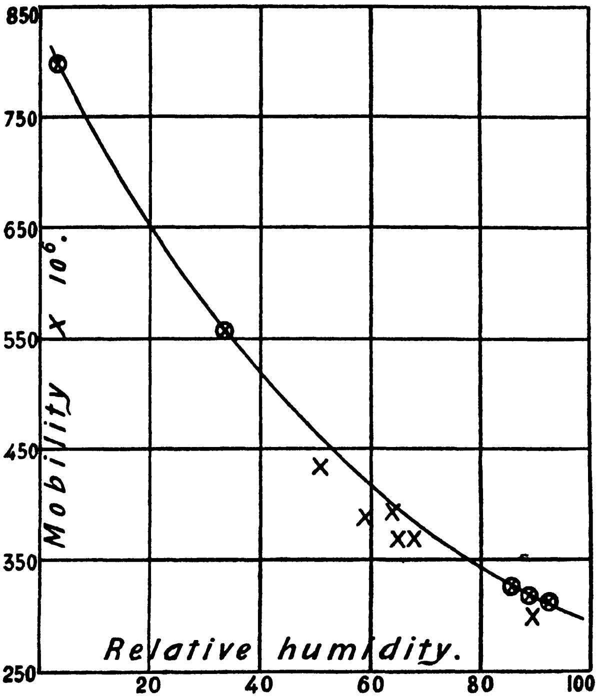
[*Read before the Royal Society of N. S. Wales, October 1, 1909.*]

IN a previous paper[1] measures of the mobility of the large ions in the air, for various values of the humidity, were given without discussion as to the form of a possible relationship between the two quantities. Further investigation of the properties of these ions has yielded additional results which are collected in Table I, all the observations being reduced to the standard pressure on the assumption mentioned in the former paper.

Table I.

Date.	Temperature.	Pressure.	Average Relative Humidity.	$1/k_{760}$	$k_{760} \times 10^6$	Mean $k_{760} \times 10^6$	Number of large ions per cm^3.
1908							
April 7	20·9	772	59	2570 –	389 –	...	3290
„ 8	„	„	64	2550 –	392 –	..	4170
„ 8	21·3	770	65	2730 –	366 –	...	32900
Sept. 14	15·3	763	51	2310 –	433 –	...	6105
1909							
June 4	16·4	761	89·5	3350 +	299 +	...	2780
„ 18	15·4	761	85·8	3140 –	318 –	...	1710
„ 18	„	„	„	2980 –	336 –	325 –	980
„ 24	18·2	757	„	3120 –	321 –	...	680
Aug. 13	16·8	759	92·5	3085 +	324 +	...	650
„ 16	15 0	768	„	3360 +	298 +	310 +	1120
„ 18	15·9	767	„	3260 +	307 +	...	900
(Lusby's observations)[2]	23·5		68·0			367	

[1] Pollock, this Journal, p. 61. [2] Lusby, this Journal, p. 55.



The whole evidence is now graphically shown in the figure. From the diagram it is seen that the observations, irrespective of temperature, when plotted against the relative humidities approximately follow a curve, which, from considerations of relative weight, has been drawn through the mean values of the grouped measures previously given. Although the observations are not as accordant as could be wished, still it is sufficiently evident that a definite relation exists between the mobility of the large ions and the humidity of the air, the form of which is, at least, indicated by the given curve.

The determination of this fact furnishes a partial clue to the nature of the ion, but before considering it I wish to refer to further experimental results which afford evidence

as to the character of the foundation of the complex structure which is indicated.

It is well known, since Aitken's notable work on the subject, that under ordinary circumstances the air is crowded with particles in suspension on which the water vapour condenses into visible drops if the air becomes slightly supersaturated. These particles, whose number varies greatly from time to time, can be removed by filtration of the air through cotton wool, or by settlement with the drops formed during repeated expansions, and as shown by Mr. C. T. R. Wilson[1] are, in fact, necessary as nuclei for visible condensation with supersaturations less than fourfold. In general these nuclei are electrically uncharged, and whatever their exact nature are conveniently known as dust particles.

In describing an atmospheric ionisation recorder, which in their hands has already yielded important results, MM. Langevin and Moulin[2] mention that the simultaneous variations in the numbers of large and small ions in the air are opposed in direction, a fact which is also shown in the measures made on the few occasions when we have taken continuous observations of both classes of ions in Sydney. MM. Langevin and Moulin further state that the number of large ions is the greater the more numerous the [dust] particles in the air, and they consider the large ions as created by the attachment to these neutral particles of small ions in the process of their diffusion. Further evidence in support of such a view is afforded by the results of the following experiments.

With the testing pipe described in the previous paper, all the large ions as well as the small ones can be withdrawn from a stream of air; in this way the pipe may be used as

[1] Wilson, Phil. Trans. A, 189, p. 265, 1897.

[2] Langevin and Moulin, Le Radium, 4, p. 218, 1907.

an electrical filter to remove the ions without removing the unelectrified dust particles. After filtering out the ions in this manner the steady state between the creation and disappearance of small ions is again established, under ordinary circumstances, in a few seconds, while for the large ions Mr. Lusby's results (*loc. cit.*) indicate that the new equilibrium condition occurs in about twenty-two minutes. I have now measured the mobility of these recreated large ions thirty minutes after the original ones had been withdrawn, and find a value appropriate to the humidity as shown by the relation given above. The observations were made in June and August of this year and are included in the foregoing table. The result proves that large ions are naturally produced in dusty air.

If the air is filtered through cotton wool the incoming dust is removed as well as the ions, but I have not yet succeeded in showing an absence of large ions in the air stream in this case, doubtless owing to the impossibility of getting rid of all the dust in the tubes through which the filtered air flows before reaching the testing pipe.

The non-existence of large ions in dust free air can, however, be inferred from the results of investigations on the formation of clouds in closed vessels. Mr. C. T. R. Wilson[1] has shown that in such experiments with natural dust-free air the first visible condensation takes place on small ions when the expansion ratio reaches the value 1·25; a special search at this laboratory has failed to show any change in the limiting supersaturation necessary for the formation of visible drops with time, extending to days, after the removal of the dust, so it may be concluded that large ions are not produced in dust-free air.

For experiments with fogs in dusty air an apparatus was employed similar to that described by Mr. Wilson in the

[1] Wilson, Phil. Mag. June, 1904.

paper just mentioned. In order to get small expansion ratios the glass cylinder in which the clouds were formed had a volume of 8647 cubic centimetres and the piston was reduced to a pipe 2·3 centimetres in diameter. The cylinder was divided vertically by an earthed metal plate on one side of which and parallel to it was an insulated one, so that an electric field could be established in one half of the vessel. With this apparatus dust motes could usually be seen in the beams of light which were used to illuminate the two halves of the cylinder, and the first condensations visible on expansion occurred for pressure differences represented by about 1·5 centimetres of water. Comparative observations were made with the field off, and on for a sufficient time before expansion for all the large ions originally present to be attracted to the plates, but we have, so far, been unable to find any influence of the field on the limiting expansion ratio required for noticeable condensation.

The attachment of small ions to dust particles can, however, be readily shown, for if the air in the expansion chamber is exposed to Röntgen rays while the field is on, the clouds on the field side of the vessel get less and less dense the longer the time of application of the rays before expansion. Under the conditions of the experiments, if the rays and field were on for about forty minutes before expansions giving pressure differences of two to three centimetres of water, only a few drops were formed in the field side of the dividing plate while dense fogs appeared in the other. Obviously sufficient small ions were produced in the interval before expansion to electrify by their attachment nearly the whole of the dust particles present, those in the field side being then carried to the plates by the electrical forces and the space on that side of the dividing plate thus cleared of condensation nuclei. This

manufacture of ions of feeble mobility by the artificial production of small ones has been shown in other ways by M. de Broglie.[1] For help with these condensation experiments I am indebted to Mr. G. W. Sinclair.

The results just given show that ions with the characteristic mobility of natural atmospheric large ions are formed in dusty but not in dust-free air, and support the view of the production of large ions previously mentioned as deduced from their observations by MM. Langevin and Moulin. In addition, the measurements collected in the earlier portion of this paper, by establishing the existence of a definite relation between the mobility of the large ions and the humidity of the air, afford proof that the ions are composed, in part at least, of water molecules. These determinations throw considerable light on the question of the structure of the natural large ion, and on the whole evidence the picture most readily formed is that of a small ion attached to a dust particle round which water molecules are collected, even in unsaturated air, to an extent depending on the humidity.

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[1] M. de Broglie, Thèses presentées a la Faculté des Sciences de Paris, Gauthier-Villars, Paris, 1908.

CORRASION BY GRAVITY STREAMS WITH APPLICATIONS OF THE ICE FLOOD HYPOTHESIS.

By E. C. ANDREWS, B.A., Department of Mines, Sydney.

Parts I, II, III.

[*Read before the Royal Society of N. S. Wales, November 3, 1909.*]

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Introduction.—The scientific investigator is repeatedly confronted with the "end results" of a series of physical and chemical activities, and he is continually at a loss to explain their existence, owing to the more or less complete obliteration of the traces of the various steps by which such "end results" were obtained. If the investigator were placed amid such favorable surroundings that the whole series of operations involved in such an "end result" could be made visible it would be found that the most complicated processes (as we now consider them) would admit of very easy explanations. Certain it is that the explanations or statements of all important natural laws

so far discovered are excessively simple, and it would seem that ingenious and complicated explanations of natural phenomena scarcely need serious attention. Nevertheless that which is easily understood when discovered may only with great difficulty be brought to light for the first time.

The chief difficulties in this connection lie in the general lack of the "scientific use of the imagination" by the ordinary investigator, and in the ephemeral existence of man, the individual, as compared with the duration of the activities he may be considering. To make up for this lack of imagination while conducting scientific investigations a valuable suggestion is often afforded by the chance observation of an "end result" which one has obtained in a short period of time, and which is similar in a general way to the one under examination. Especially valuable is such a suggestion when the various steps in the process of the development of the chance "end result" may be readily seen and appreciated.

Such similar "end results" may have been obtained by experimenting with substances quite different from those in which the special "end result" that the scientist is investigating has been reached. Furthermore the activities concerned in each case may not have been identical. Nevertheless, such suggestions frequently have led to actual proof of the particular problem which may have been under consideration. As an illustration of this we may mention the special case under consideration, namely, the common principles underlying gravity[1] stream action and the application of such principles to ice action. It will be seen, as the following notes are read, that the underlying principles of ice-stream action could scarcely have been appreciated by a study of modern glaciers only, but

[1] Throughout this note the word "stream" will be used instead of the term "gravity stream."

that they depend for their understanding upon a suggestion derived from a consideration of streams in general; and that general stream principles in turn again may only be appreciated after actual observation of the successive steps in the development of land profiles which have been formed by one or more stream types.

Half a century ago Ramsay explained the profiles of certain Alpine Lake Basins as those due to the action of ice. Nevertheless, the observed action of present-day glaciers apparently[1] does not bear out his statements. (This does not necessarily prove that Ramsay was wrong, but it does show, however, that Ramsay missed at least one link in the chain of evidence). Then came the inductive studies of such observers as Chamberlin, Davis, Gilbert, Tarr, Penck, Gannett, Bailey Willis, W. D. Johnson, Salisbury, J. Geikie, McGee, Reid, Matthes Blandford and others, by whom it was demonstrated that certain land profiles were always and only found in regions which had been but recently deglaciated. Moreover, they showed that in proportion to the intensity of the glaciation to which a region had been subjected so had these "peculiar" land profiles been correspondingly emphasised.

A very valuable suggestion was thus afforded, nevertheless, this evidence in itself was not sufficient to actually prove that these land profiles were due to the action of glaciers.[2] With the progress of time additional light was shed on this subject. Thus in a description of the famous amphitheatres in the Red Wall Limestone of the Colorado Canon, Davis[3] showed how such profiles have been determined by weathering and by stream action. He described the avalanche also as a stream. Then later, from comparative stream studies also, came the knowledge that certain

[1] See Culver, Fairchild and references quoted therein.

[2] See Culver, Fairchild and references. [3] Davis (d) pp. 176 - 180.

profiles which had been developed by water action were productive of channel forms similarly shaped and similarly situated to those previously supposed to have been peculiar to valleys which had been but recently deglaciated. Hence arose the idea that comparative stream studies might suggest the explanation of the topography of recently deglaciated valleys; not indeed was it thus thought that ice, water, viscous and rock masses would be ascertained to move and act in the same way, but rather that some important principles might be found common to all; principles possibly quite familiar to everyone in connection with certain stream types but not suspected in connection with other and less mobile types.

The following papers are illustrative of principles so found, and descriptive of the land profiles formed which depend on the action of such principles. Thus it was ascertained[1] for water channels that trenches with straight sides, hanging valleys, basined floors and valley heads of cirque-like appearance were rapidly developed as the result of heavy water action, such as may be seen in arid or other countries during thunderstorms, or even rainy seasons, and that decrease of the stream velocity was attended by relative incompetence of[2] the stream with:—

1. Aggradation of the channel basins.
2. Readjustment of the channel grades.
3. Excavation in the stream debris of miniatures of the profiles formed during the flood stages.

With these may be compared the forms formerly supposed to be peculiar to valleys recently deglaciated. Thus the fiord and Alpine lake basins, the facetted and much demolished spurs, the cliff-feet or cliff-bases rectilinearly disposed, the hanging valleys and the large cirque forms both along Alpine Valley bases and heads, are all apparently

[1] Andrews (b). [2] First announced scientifically by Gilbert.

matched in miniature by the channel profiles formed by flood waters.[1] Furthermore it was well known that:—

1. Many glacierets and glaciers to day exhibit such feeble flow phenomena that they have preserved their original banded structure from head to foot. Along the same valley for many miles below the present glacial foot abundant signs of violent glacial action in recent times are shown by the deep tortuous glacial grooves which wind round and over the rock masses. (Such strong glacial markings characterise basal constrictions in canons such as those of the Californian Sierras).

2. Glaciers, in recent times, were of much greater volume than they are at present.[2] This is implied by the statements in the preceding paragraph.

3. Present day glaciers, wherever they are amenable to such examination, appear to be the least competent as corraders at those places where, on the assumption of the ability of glaciers to corrade channel structures, they should be excavating most rapidly. (In this connection see Culver and Fairchild quoted under Literature).

These facts suggested for ice streams that increased volume tended to produce increased mobility or plasticity, and that increase of velocity was productive of corrasive strength rising in a high geometrical ratio.[3]

But for the same channel this would imply a marked decrease in plasticity or mobility upon the decrease of stream volume. This would imply also a still greater reduction in corrasive power. In other words, upon reduction of volume, the glacier would now commence to aggrade the channel

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[1] Andrews, (b).

[2] See however, Gregory, p. 6, lines 19 – 21. Nevertheless in every glacial region examined up to the present, the evidence of the pronounced deglaciation of valleys is everywhere present.

[3] Gilbert has shown this for ordinary streams (a) pp. 89 – 91.

base and sides at the points where the greater glacier had exerted its maximum corrasive strength, and such aggradation and relative glacial stagnation would ensue until the channel grades had been readjusted to the new conditions.

The significance of this is briefly as follows :—Very large glaciers have been acting along certain valleys; these large ice masses have only just vacated the valleys, and dwarfed glaciers now occupy their places. The plasticity of the present day glaciers is much less than that of the preceding flood glaciers, and if we assume that glaciers are capable of even slight corrasion, then the action of the dwarfed glaciers of to day along the same valley is altogether different to that of the recent glaciers. Instead of studying present day glaciers as models of the corrasive action of ice during the recent Ice Ages, we should rather beware of pitfalls by such study just as students of water streams should beware of attempting explanations of river channel formations before they have observed the action of a large flood, otherwise they may be tempted to deny the power of the stream to excavate deep potholes or basins in the channel base and sides because the normal stream is practically inert at such spots.

Furthermore, it will be seen that all streams must conform to certain underlying principles from the very conception of stream flow, seeing that gravity, the stream maker, is a constant vertical force at the earth's surface, ever compelling the stream to take the lines of least resistance.

In the case of a vertical force this implies the necessity of the stream, as a unit, to take the line of quickest descent. The stream may be conceived as a group of textural units possessed of greater or less individual coherence. As pressure (by volume or increased speed) asserts itself such

coherence of the textural units is gradually overcome and differential motion, or flow, ensues. Even a crystalline solid may be forced to flow under great gravitative stress. As opportunity offers, such stream material will revert to its solid condition, and a stream thus induced, and possessed only of the atmospheric cover, may present the appearance of a rigid solid at one place, a typical stream at another, and a quasi-plastic compromise to gravity in the intermediate region. Something akin to this state of affairs apparently occurs in modern glaciers. In the glacial "slacks" one gets the idea of a crystalline solid; below a variable englacial surface there is apparently a plastic response to gravity, while the main mass exposed to the air is at least a compromise between these two types. Of course this has reference only to glaciers of a definite size, or to fairly large ice masses working along declivities or in valley constrictions. Up to such stage an ice mass may only present a feeble response to gravitative stress. (A good example of the latter stage is the ordinary ice block sold in towns. Very valuable information as to the ordinary properties of ice—such as regelation—may be obtained from a study of such ice cubes. Nevertheless, the inferences of a student whose knowledge of ice was confined to an acquaintance with such ice cubes would not be very valuable in any discussion as to the probable origin of fiord basins by glacial action).

Again, many potential streams may be conceived as possessing various sets of textural units. Under one set of conditions, flow may take place by differential movement between one group of textural units, while under greater gravitative stress, flow may be transferred to another set of units. Thus a heap of bricks may form a gravity stream, the individual bricks forming the textural units of such a stream. Under increased pressure the bricks may be

crushed and flow may be transferred to the sand and clay fragments composing the bricks. Still greater pressure may destroy the individuality of such fragments and flow may depend finally on the differential motion between the various molecules of these substances. Yet in each case the stream characteristics are retained, the mass, as a whole, in each case seeks the lines of least resistance, the lines of quickest descent. This implies the necessity of the various stream types to follow the thalweg,[1] when turned into any stream-formed valley, from considerations of vertical pressure. The thalweg in all cases may be seen to be the locus of maximum corrasive energy.

It will be seen at a glance how this gives us a basis of comparison for the various stream types as regards their ability to transport infra-stream material; and as regards the locations and values of variable stream velocities.

Certain interesting results are obtained from a consideration of such data, and these are discussed in detail in the following pages. Thus to quote two results only out of many:—Stream recession on declivities is seen to result, primarily, in a resolution of the channel bed into a succession of "steps" and "treads," the steps being approximately of cirque-shape with or without basins on the treads. In proportion as the cutting-back of the declivity is accompanied by rapid increase of channel cross-section, so is the feature of the basin formation seen to be less emphasised. The action in the formation of typical cirque or cup-shaped forms is seen to be dual or even triple. The channel basin, if any, at its foot is mainly an expression of stream corrasion at the point where the greatest percentage of stream strength may be expended. Such point occurs where the slope of the channel bed presents the least angle (as at the foot of a waterfall or a cascade) to

[1] Path taken by a stream down a valley.

the general plane of the descending stream, because the percentage of stream energy expended as corrasion is reduced in proportion to the steepness of the declivity. The cirque profile immediately above the basin or flattish floor arises as a compromise between the forces of sapping and the action of the descending stream. The uppermost portion, as the factor of stream weight diminishes, will represent the atmospheric slope of repose mainly and will have a less pronounced slope than that of the central portion.

We do not here insist that the forms which are peculiar to regions of former glacial intensity are the results of glacial corrasion and that the present-day glaciers must stagnate along such channels, but this we do insist on :—Grant that glaciers can corrade rock structures; grant also a period, or periods, of glacial action which has, or have been, productive of much more intense action than the glaciers of the present time; and that such intense action has only just departed, then the present-day glaciers must appear to stagnate at just those points where the greatest activity of glaciers is demanded by the hypothesis of lake basin origin or "valley deepening" by glacial corrasion.

The first part of this series is devoted to a discussion of the general stream. Part (2) deals with an application of these principles to ice-action, while in Part (3) applications of stream principles are made to specific areas where deglaciated valleys occur in great abundance.

The writer especially desires to record his thanks to Dr. G. K. Gilbert through whose kindness and in whose company he was enabled to spend some five weeks in the Californian Sierras during the summer of 1908. Owing also to Dr. Gilbert's friendly criticism of the writer's glacial note of 1907, the present simple proof—drawn from mechanical and comparative sources—has been attempted of the con-

clusions already arrived at in other ways by Davis, Gilbert, W. D. Johnson, Penck, Tarr and others; conclusions perhaps stated the most convincingly by Davis.[1] W. D. Johnson also was one of the Sierran Party and to him the writer is indebted for a discussion of glacial problems during the trip. To Professors Davis, Chamberlin, Tarr, Daly, J. W. Gregory, Harker and Marr the writer desires also to record his thanks for reading and criticising the report in part, or in whole, while in manuscript; and also to Professors Tarr, Marr and J. W. Gregory, and to Mr. Von Englen of Cornell for their kindness in showing him numerous localities of great glacial interest. For incisive statements as to the mechanics of glaciers the reader should consult:—W. J. McGee, Glacial Canyons, Journ. Geology ii, 1894, pp. 350–364; H. F. Reid, The Mechanics of Glaciers, Journ. Geol., iv, 1896, pp. 712–728.

Some Characteristics of Streams.—The volume of a stream and the topography traversed determine the relative ease or difficulty with which the stream shall reach the local or main base-level. The variable motion induced by gravity between the textural units of the mass constitutes flow. Great freedom of motion between the various textural units gives mobility. The action of gravity is normal to the earth's general surface. Therefore, if we confine our attention to the considerations only of increase or decrease of velocity and the lines of direction taken by various stream masses, it is evident that whatever may be the stream composition, each will respond in a similar way to gravity (but of course not quantitatively) when traversing similar topographic profiles, for a fixed vertical force at any spot has also a fixed component along a slope possessing a fixed angular value.

Surface of Stream.—Each stream, considered as a whole, must have a surface declining in the direction of flow.

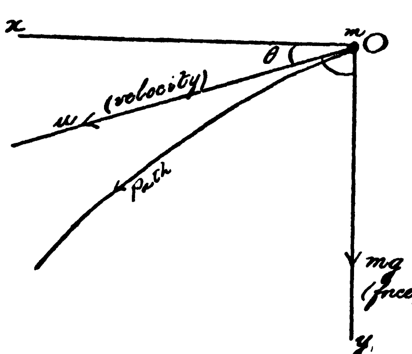
[1] Proc. Boston Soc. Nat. Hist., xxix, 1900, pp. 277–322, also Davis (c).

Channel Slope.—All other things being equal, stream velocity is increased in proportion to the increase of slope of channel base.

Increase of Stream Volume.—From considerations of pressure this implies increase of velocity.

Path of a Stream Particle.—The descending stream is always tending to parabolic motion from a consideration of the dual action on a stream particle at any point. Gravity attempts to impart a vertical motion to the particle but is prevented, as a rule, from doing so owing to the resistance offered by the earth. The motion of the particle is thus deflected at some angle to the vertical. This again tends to hold the particle in the new direction, but as opportunity offers, gravity again tends to impart a vertical motion to it. Thus the result is a compromise between a motion possessing a more or less horizontal value with one possessing a constant vertical value. The tendency is thus to parabolic motion. (See mathematical proof in appendix).

Fig. 1.



Path of a Stream Particle.

In the figure the path of the particle is shown as a curve convex to the sky. This is the path when the particle is free to move in all directions. In nature the resistance of the earth's crust comes into play, and the path becomes more or less parabolic by the aid of corrasion or aggradation.

The corraded path is concave to the sky, *i.e.* an approximation to the axis (y). The aggraded path is convex to the sky, *i.e.* an approximation to the axis (x).

Definition of Terms—Channel constrictions.—A constriction is that portion of a channel where the cross-section is relatively small.

Constricted channel confluence.—This is the point of junction of two or more channels, the sum of whose cross-sections exceeds the cross-section of the main channel at the point of junction.

Channel "Broads."—These imply valley cross-sections passing immediately upstream into areas of less cross-section.

Channel "Diffluences."—Here the sum of two or more channel cross-sections is considered as less than the cross-section of the channel into which they discharge. As in the case of a channel "Broad" so here velocity will be decreased.

Transportation of material.—No stream moves as a rigid bolt, except possibly when falling freely. As the volume increases the friction between its textural units becomes of relatively less importance and greater mobility is attained. This is true whatever the stream material considered. This increasingly prevents the stream holding its tools stiffly to their work, and causes it increasingly to depart from the action of a plane. In proportion to the mobility and strength of a stream so will the transported material take on a saltatory motion.

Stream motion round small obstacles.—Upon the slope facing upstream the stream has a greater action, while upon the downstream slope a less percentage of the stream velocity takes effect (Fig. 1). The work of passing the small obstacle represents a net loss to the stream power.

Stream motion around rock masses large as compared with the passing stream.—The upstream portion of the mass acts as a dam and destroys the individuality of the

stream until the mass is surmounted. The downstream slope offers a path for the surmounting stream. Gravity asserts itself on the stream mass here partly as flow and partly as a falling motion, and this new stream motion is an expression of the steepness of the channel base traversed. This change from inactivity to activity represents a net gain to the power of the stream.

Differential motion and shearing.—It is evident in streams flowing under the action of gravity that every obstacle in the channel causes differential motion to be set up locally. The stream always follows the lines of the least resistance as it must do from the nature of its origin. Differential motion is thus set up. With increased mobility comes increased ability to express eddyings. Under sufficient pressure or gravitative stress the most refractory stream may acquire wonderfully increased powers of mobility with corresponding ability to emphasise differential motion.

With increasing friction of the channel bottom and sides comes rapid decrease of velocity among the basal portions. The lower stream layers experience retardation while the more superficial portions suffer much less from friction and tend now by their momentum to move over the lower layers. Strong reflections are caused from side and bottom obstacles because of this nature of the stream to follow the lines of least resistance. In many mobile streams whole masses may thus be hurled bodily above the stream surface. In the less mobile masses and those which are apparently almost or quite solid under conditions of ordinary atmospheric pressure, the differential motion often expresses itself as shearing. The stronger the stream or the greater the increase of its velocity, the more pronounced will be these shearings and projections upwards and outwards from the general surface. Nevertheless, as such shearing

and variable motion increase in violence the actual strength of the stream increases greatly in spite of this loss of energy by internal work.

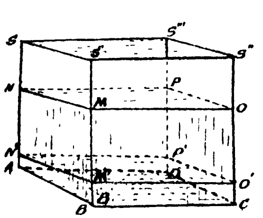
Stream velocity in channels.—(See Fig. 2 *a.*)—Let N‴ O N‴ be a stream channel, O a point on the thalweg, and let N′N′, N″N″, N‴N‴, and PP′ represent varying surface levels of the stream. Let the channel section be symmetrically arranged about a vertical plane OL. For the first three levels the stream is confined to the channel proper while for the last mentioned level the stream overflows the banks of its channel proper. Since the channel is assumed to be developed by corrasion the stream material has a get away and therefore the problem is not one of hydrostatics. From considerations of pressure and friction of channel sides it will be seen that the greatest stream velocity lies above the thalweg and at a point not in contact with the sides. But when friction is zero the greatest velocity is at O and the stream suffers gradual diminution of velocity in a direction from O to L.

Now if we confine our attention to the action of a stream when in contact with the channel sides we shall find that, all other things being equal, the greatest velocity of that portion of the stream which is in actual contact with its channel structures lies at O and the velocity is progressively weakened from O to N‴. Thus at O it may be very great, while almost negligible at BB′. Again, the higher the stream rises above L the greater becomes the velocity at O. This is a very important point when considering corrasion and it applies to all gravity streams alike.

Corrasion by Streams.—*Preliminary.*—If a rock fragment be struck by, or be dragged over, another rock fragment, a mutual loss is sustained. If one be more resistant than the other, then it suffers less from the impact than does the less resistant one. Earth material thus corrades

live rock structures over which it is dragged. So long then as any stream has power to move the total load overlying any area, large or small, of the channel structures, so long will that stream have power to cut vertically or laterally into the rock structures forming the channel base or side at that particular point, for by moving the total load at that point it drags it over the live rock structures. If the stream flows over the channel debris however without urging it along as a whole at any one place, it is not corrading at that spot. Thus when the stream volume is much reduced the corrasion is of very limited extent, while in times of great stream volume, when the load of earth material is rolled along in its entirety at many places, great corrasion of the channel bed and sides ensues.

Fig 2 (b)



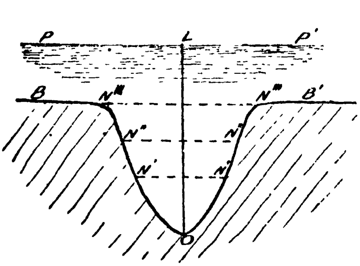


Fig. 2 (a).

Let us consider this a little more in detail inasmuch as its proper understanding is necessary in stream studies so as to prevent any confusion of the terms "corrasion" and "aggradation."[1]

In Fig. 2 (b) let ABCD represent a unit area of a channel bottom, NMOP the upper limit of a load of stream debris, and SS′S″S‴ the stream surface. We assume the channel base to be unaffected by outside influences (such as those

[1] As an example we sometimes hear of the "sheet-flood erosion" of wide valley bottoms, when an examination of the evidence shows that "sheet-flood" aggradation (not erosion) of the valley floor is apparently indicated.

of elevation or depression) during the period under consideration.

If now the stream moves the mass of debris whose height is M B bodily over the channel base A B C D then corrasion of the base A B C D must ensue. If, however, the stream has power merely to roll the upper mass, say of height M M′, over the lower stream debris (of height B M′) then the stream cannot corrade the channel structures at that point—that is to say it does not accomplish "work" at that spot, for in order to accomplish land dissection or peneplanation a stream must have a vertical measure of strength sufficient to allow it to remove the debris and to get at the channel base proper.

Principles common to stream corrasion.—We have ascertained already that each type of stream will tend to experience increase or decrease of velocity under certain similar conditions; that each will take practically the same route to base level (allowance being made for the magnitudes and velocities of the streams considered), each taking the line of least resistance. This indicates that the corrasive action by streams is somewhat analogous in general aspect.[1]

It will now be advisable to ascertain the existence of the relations between increase of velocity and the energy of streams. As an example, suppose that the velocity of any stream be doubled. Viewed from the standpoint of stream impact, the doubled velocity is at least four times as effective as the initial one, for now, in any given time, twice as much stream material acts upon a given point with twice the velocity as compared with that of the point acted on by the stream when possessing the original velocity. If the velocity be trebled, then three times the amount of stream material passes a given point in any given time with

[1] See also Appendix.

three times the velocity as compared with that of the point acted on for the same time by the same stream when possessed of its original velocity. The power of corrasion by such a stream appears therefore to vary at least as the square of the velocity. But this takes account only of such material as the stream is enabled to transport with the smaller velocity and does not take account of the additional material which the accelerated stream is enabled to transport. For mathematical proof see Appendix III.

Similarly it may be shown that the transporting power of gravity streams apparently varies as the sixth power of the velocity when all other things are equal. (See Gilbert also (a) pp. 89 – 90 for the case of water streams). Thus in all streams we see that energy is not simply related to increase of stream velocity, but that it rises in some high geometrical ratio with increase of velocity. It will be important to keep this principle continually in mind during the present discussion as only by means of this can we hope satisfactorily to explain some well known topographic features.

Stream strength as compared with channel structures. —In this note we are concerned only with streams which either exist to-day or which may have existed in recent geological time. In nature, mobile streams never attain enormous dimensions as compared with their topographic surroundings. They have not the momentum necessary to shatter the rock structures which they traverse, and thus they are unable to tear out huge slabs along, or across, dominant joint faces. They have power to drag loads over the structures forming their channels and thus to scour and strongly abrade, but their strength of impact is rarely sufficient to overcome the coherence of the more important rock structures.

If now for the very mobile stream a crystalline solid be substituted, which responds to gravity as flow only when

under the influence of enormous pressure, then by greatly increasing its volume, the friction between its textural units may be overcome and a stream formed of the mass. The momentum in this case will probably be so great that the very force of its impact upon the channel bed and sides —especially when it is armed with a rock load—may overcome the coherence of the ordinary rock structures[1] and allow it to quarry huge masses along, or across, the main joint planes. At the same time it will be able to strongly abrade the fresh surfaces thus exposed to its influence by the quarrying action.

Phases of stream action considered.—It will be advisable to consider:—

(a) the initial form produced in each of these cases by stream action; then to consider:—

(b) the subsequent history of such corrasive forms when the stream volume is considered as still constant; and

(c) to mention briefly the significance of a reduction of stream volume.

Geological Assumptions.—We will suppose—unles otherwise stated—that the rock structures acted upon are homogeneous, having joints well developed and not set very widely apart, and that the rocks, moreover, are homogeneous both in texture and in mineralogical composition. From this simple case the other more complicated ones may be appreciated quite easily.

A. *Initial Corrasive forms.*

(1) *Along channel bottoms of negligible slope, and at locations of channel constrictions.*

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[1] The plasticity of the mass also under such great stress will help it to exercise great quarrying action by moulding itself closely to the channel bed.

Two cases may here be considered :—

(i) That in which the channel constriction is symmetrically disposed with respect to the main chanel axis.

(ii) That in which the constriction is not symmetrically arranged with respect to the main channel axis.

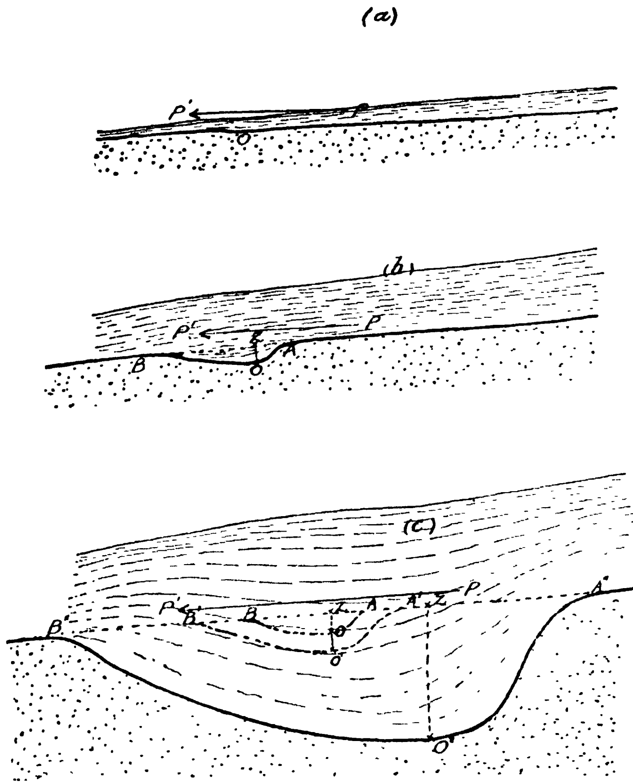
(i) Channel sides symmetrically arranged with respect to the main axis.

The composition of the stream need not concern us here. So long as gravitative stress urges it toward the base level so long will it corrade the channel structures with which it comes in contact. In the ideal case we have chosen to consider the stream action is the same on each side of the main valley axis.

In Fig. 3 (a) let P P′ represent a longitudinal section of a stream flowing through a channel constriction where an increase of stream volume has been just set up, and where the stream is dragging earth material over the live rock of its channel base and sides. We will suppose the case of a channel bottom of almost negligible slope. Now from gravitative considerations the cross-section of the stream when traversing the constriction is less than the cross-section of the broader part of the channel farther upstream, therefore the stream has its velocity increased while passing along the channel "narrow." But for a similar reason the narrower portions of this general channel constriction will cause the stream velocity to be relatively quickened in turn at such spots, and rock material will here be dragged more quickly over the channel base than at other points in the constriction and the stream will cut more deeply at these points. Increase again of the corrasive power of streams is not related in a simple ratio to increase of velocity, and therefore a slight increase of stream velocity may be associated with a pronounced increase of corrasive

power. That is to say, an excavation will here be made below the associated base levels; or, stated more correctly, the stream will here produce a local (temporary) base level occupying a lower vertical position than the local base levels associated with it.

Fig. 3.



(a) P P' = direction of stream.
O = assumed location of increased stream velocity caused in various ways.
(b) A O B = basin of corrasion formed during local increase of stream velocity.
Z O = vertical measure of the corrasive strength of the stream.
(c) Various dimensions of rock-basins determined by variable increase of stream volume (velocity).

Let the excavation A O B express such variable stream action. [Fig. 3 (b)]. The question may now be put:—what is the measure of the extent of this vertical corrasion; in other words—what is its downward limit?

As has been pointed out already no stream can mechanically corrade its channel base at points where such base is occupied by stagnant debris. If the stream in its passage should override debris without moving it, then it is not corrading its channel base and sides. For example, if the channel base is cumbered with debris 1,000 feet in depth and the stream can move a thickness of 999 feet only of the debris at any spot. it is not corrading its channel structures at that point. At such a point it is simply readjusting its grade. In other words, the stream utilises the channel bottom as a bridge for the transportation of debris toward the main base level, and at spots where it cannot move its load as a whole over this bridge of live rock it actually protects it. [Fig. 2 (a)].

The depth, therefore, of such initial basin A O B in Fig. 3 (b) will be increased until the time arrives that the stream P P′ can only just maintain its general character as a stream over the excavation while moving the mass of stream and rock material filling the excavation of A O B as a whole. Let such greatest depth be Z O. Now until the point B be lowered, the stream we are considering cannot cut below O because it has no ability to transport its load at depths greater than Z O and a stream which is unable to get at the channel structures proper cannot corrade them.

Briefly then, the stream P P′ receives an acceleration of velocity at A and excavates the basin A O B below the associated base levels. At O the limit of its vertical measure of strength is taxed in the transportation of its load along the slope A O B. The stream is therefore capable

here of no appreciable work since at any depth below O it would be forced to let its load fall out of the current. However long the stream P P′ acted, therefore, along this grade it could not lower the point O until it had first succeeded in lowering the point B.

Now suppose the stream P P′ to become possessed of a velocity eight times as great as it possessed when the basin A O B was formed. What will be the new depth of the basin? The casual observer may answer that the new basin will be twice as deep as the former one "since the force is now eight times as great." That is, he imagines the new basin will be twice as deep, twice as long, and twice as broad as the former one.

But (1) the laws of streams show that their power of transportation varies probably as the sixth power of the velocity and their corrasive strength exceeds the square of the velocity. (See Appendix III.)

(2) Under natural conditions increase of stream velocity along a definite channel originates in increased stream volume.

Let us then suppose that a basin twice as deep and eight times as large as the original one has been formed [Fig. 3 (c)], with depth O′Z = 2 O Z. The new stream P P′ with a velocity eight times increased descends the basin. As its increased velocity is a result of increased volume its transporting power is approximately now to be multiplied by 8^6, *i.e.* by 262, 144. Nevertheless, all that is required of it in such a basin as we have assumed is to lift or transport a burden eight times as large as its former one, the great bulk of such material lying within the vertical limit Z O, the dead work accomplished in lifting the debris from the floor of the smaller excavation. On the other hand, the stream has its transporting power increased 262, 144 times.

An objection may be raised here on the ground of stream position. Is it not possible that the stream, powerful as it is, may lose its efficiency at some excessively rapid rate below base level? This is undoubtedly so, especially if the increased velocity be attended with no increase in volume. But along the same channel, natural streams derive such great increase of velocity by means of enormous increase of volume. So long as the stream can transport the material occupying the basin as a whole, so long can it corrade the entire basin base. In the case under consideration such volume would be so great that the lifting power required to drag the stream material from twice the original depth of the basin would be a negligible quantity. This is evident also from considerations of speed apart from volume since eight times the amount of stream material now passes through any given cross-section with eight times the velocity as compared with that of the original stream. Thus the vertical measure of the corrasive efficiency of a stream will be rapidly increasing while velocity is more slowly increasing. The new basin will therefore take on some much larger dimensions such as A″O″B″. Let us call such depths as Z O′ and Z O″, (which indicate the limits of the corrasive power of the streams when vertically considered), the vertical measures of stream efficiency. The apprehension of such principle for streams generally would throw much light on disputed physiographical points, as will be shown more fully later.

But to return to the discussion of the basins so formed by streams. In homogeneous structures it is easy to ascertain the general shape of this initial depression formed below the main or local base level upon the increase of stream velocity. Its deepest portion will be situated a little in advance of the topographic configuration determining the maximum velocity along the main axis of the

channel constriction. The depth will be a measure of the mass and velocity of the stream, and in a measure also, that of the time occupied by stream cutting.

Two laws of stream corrasion in homogeneous structures deserve mention here:

(1) All other things being equal the greater the stream velocity the more will the headward profiles of the cut formed below base level by corrasion be inclined to the vertical.

(2) The more freely does the force of gravity act, the more nearly will the basin head approach a vertical form.

These follow from a consideration of the path of a stream particle and the constancy of the time factor involved. From the deepest point of the cut so determined the slope of the basin can now be determined geometrically. In Fig. 3 (c) let A″O″ represent the head of the cut, and O″ its deepest point.

Let us first consider the profile A″O″. Although A″O″ is a descent, nevertheless, it lies wholly below the associated local base level because the corrasive cut has been made locally in a horizontal channel base and must therefore pass into a reversed grade downstream. From mechanical considerations every measurement of descent made by the stream into this basin thus represents loss of velocity. For the stream derived its velocity from a point higher upstream and in order to maintain this basin bottom as the new channel grade for the transportation of debris, the stream has to lift the dead weight of the mass filling the basin, and notwithstanding this, it must still maintain its general surface slope down stream over the basin itself. This implies pronounced loss of velocity locally. But this increasing loss of velocity is accompanied by a decrease of corrasive power in a high geometrical ratio. Therefore, from point to point along A″O″ the power of the stream is

rapidly decreasing while the time factor remains constant. That is, the weaker stream portion has the same time only in which to accomplish its task as the stronger portion. The curve A″O″ has a tendency therefore to be steeper at its head than at points lower down, and at a certain point below the head determined by the volume of the stream, the curve will rapidly flatten and at the deepest point will assume tangency with a horizontal plane. (See Appendix). Thence downstream with ever decreasing stream force the curve is reversed, until it assumes tangency once more with a horizontal plane or the plane of the associated local base level. (See Appendix).

We are still confronted with the problem of the general appearance of the excavation. Before discussing this, however, it will be advisable to inquire a little more fully into the general conditions determining the cut or excavation below the associated base level.

All other things being equal, a stream which flows along a channel (excavated by itself or by another stream type) depends upon increased volume to produce an increase of its velocity along the same channel. Similarly, greatly increased volume is necessary also to produce great increase of velocity here. Therefore if great local irregularities of channel grade occur (in valleys reasonably supposed to be stream developed) the inference is that here a stream acted under conditions of great local volume and velocity combined. And this causes us to ask what are the conditions in nature which could induce such a state of increase of stream velocity locally?

Consider the action of a stream, say 10,000 feet deep:—

(a) Over the plane surface of a solid composed of homogeneous structures. Here it will appear to act somewhat as a plane, and no differential corrasion will be accomplished.

(b) Over a plane surface trenched by a narrow canon 500 feet deep. Here velocity and pressure are unifom over the upland surface, and no differential corrasion here occurs; along the canon however the pressure, and hence velocity [Fig. 2 (a)], is of much greater value than on the uplands, and corrasion is here very pronounced since corrasion increases in a geometrical ratio with the increase of velocity.

So marked would be the variable corrasion along upland and valley that a casual observer would fail to see the signs of upland corrasion in his astonishment at the evidence of relatively strong corrasion along the canon.

(c) Over a plane upland surface as before, the upland now being trenched with a narrow canon 5,000 feet deep. The action here is similar to that described under (b) with this exception, that the basin formations, and general valley over deepening, of the profound canon are now still more emphasised.

(d) Over a plane surface as before with a narrow canon 5,000 feet deep as in (c) but with a channel base possessed of a steep slope. The action is much the same as that shown for (c) but still more emphasised.

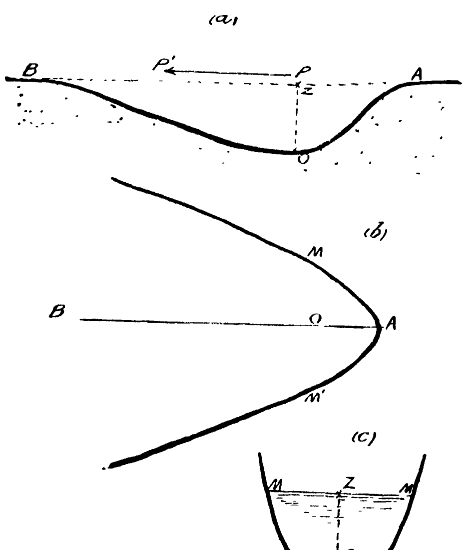
In other words a stream of whatsoever material composed and 10,000 feet deep might apparently corrade the prairies of the United States but slightly; it might act more or less as a weak plane over New York, but might still scour most powerfully along the Hudson Channel; it might scour the valleys of the Scotch or English Highlands strongly yet abrade the uplands themselves in a minor degree only, while in the case of Norway it could scour the canon bases to great depths below sea level, even if, at the same time it could only weakly abrade the uplands.

There appears to be no escape from the action of this deep underlying principle namely, rapid rise of energy with

increase of stream velocity. The law is easily grasped, but its significance in nature is far reaching. Having elucidated this point, we are now in a position to consider the general shape of the excavation formed below base level.

It is evident all other things being equal that the greatest stream velocity and strength will be along the main valley axis, and that the greatest basal stream strength will also be along this main axis. (Johnson discusses a somewhat similar action, pp. 576 – 577). The deepest point of the excavation will therefore be along the valley axis. It is clear also that this maximum corrasion will cause the point of the excavation lying farthest upstream to lie along the valley axis while the progressively weakening lateral action will cause the upstream rim of the excavation to present a concave[1] aspect downstream as M A M′ [Fig. 4 (a) and (b).

Fig. 4.



(a) Longitudinal section of rock basin excavated along a former channel grade of negligible slope in a channel constriction.

(b) Plan of such rock basin.

(c) Transverse section of such rock basin.

[1] The general case is considered in the appendix.

It is also evident that with increased stream velocity, all other things being equal, the slope A O will tend to be increasingly flattened. Sapping is also set up, and the path of a stream particle hints also at the profile thus obtained. Information is also at hand to ascertain the nature of the side and bottom profiles of the excavation. Of course, in the ideal case under consideration, the profile O M is a duplicate of the profile O M′. [Fig. 4 (c)]. As to the angular values of the slopes M O and M′O our slight excursion into the consideration of the conditions favouring increase of stream velocity has prepared us for the discussion of such. Thus, to take an extreme case, namely, that of a relatively small cross-section of a profound canon when a stream occupies the whole valley. Here we have the conditions for the formation of great basin depths along the channel bottom or at least for the formation of marked over deepening of the valleys. The stream now seeks the lines of least resistance, and owing to its enormous thickness it delivers (near its base) great lateral, as well as great vertical and longitudinal pressures. This great lateral pressure is productive of steep cliffs by means of under cutting and consequent sapping action. In the extreme case immense vertical cliffs may be formed by such action.

Briefly then, excavations such as we have been considering are more or less cup-shaped at their heads. The conditions favouring the formation of deep basins (below the associated local base levels) with flattish floors and steep sides are :—

(a) Great stream depth as compared with the width of the channel base.

(b) Great local increase of stream velocity.

Constrictions along a Crooked Channel.—If bends occur in the channel constriction then the greatest corrasion will

follow the line of greatest velocity taken by the stream. The basin of corrasion will here be formed in much the same manner as has been shown in the previous chapter, but it will not now be symmetrically situated along the axis of the channel constriction, but will be situated closer to one side than to the other. The valley wall associated with this deepest point of corrasion will be selected for more severe attack than the opposite one. [Fig. 5 (b)].

This side then becomes the main portion of the cutting curve. This form will receive attention later. This and the following ideal forms are, of course, adduced on the assumption of homogeneous structures not large as compared with the stream volumes. In nature the cup-shaped head is not always formed owing to the heterogeneous character of the structures acted upon. Again, angular V shaped heads (as also channel bases) are frequently formed because of incipient corrasive action only being set up, and because of the presence of strong joint systems arranged at acute angles with each other. (This is well shown in Yosemite valley details as will be mentioned later).

Let us consider the cutting curve a little in detail otherwise misconception may arise as to our meaning of the term "resultant direction" of the stream's velocity. In the figure (Fig. 5) the stream is shown as acting along a definite line, and operating at one definite point. From the nature of the case the stream cannot act at one definite point only, but will act upon a whole bend of its channel while leaving the opposite side comparatively protected. Nevertheless there must be a point of maximum—as also one of minimum—velocity and corrasion in every such bend of the channel, and the location of such point of maximum corrasion along a cutting curve it is that is indicated by R (Fig. 5). Thus a small tributary stream may formerly have entered the main channel approximately with accordant grade at the

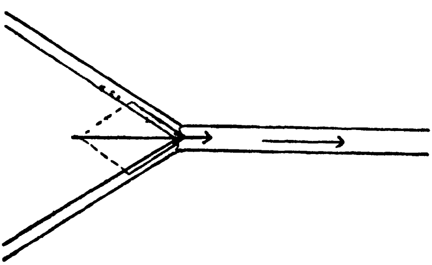
point A [Fig. 5 (c)] on a cutting curve. Under the later conditions of greater stream volume for the main channel such as we have just been describing, this tributary mouth may be cut back to the point B Fig. 5 (d). Nevertheless this may not mark the maximum point of corrasion along such a cutting curve, the maximum corrasion being located at C in Fig. 5 (e). It is evident indeed that with each alteration of volume the point of maximum corrasion must vary along any cutting curve. This is a point needing special attention when studying the causes leading to the formation of Hanging Valleys in glaciated regions. This subject is treated more fully in Part II of this Series.

A channel confluence forming a constriction.—Here the sum of the cross-sections of the tributaries is larger than the cross-section of the main stream at or near the stream confluence. We will suppose the channel grade to be very slight or almost negligible. The case is now similar to that of corrasion in a channel constriction. The more pronounced the constriction of the main stream the more accentuated will be the increase of stream velocity at that point. This again implies greatly increased stream energy. So long as the stream has power to utilise its basin bed as a bridge for the transportation of its load proper as a whole, so long will corrasion have a vertical component there.

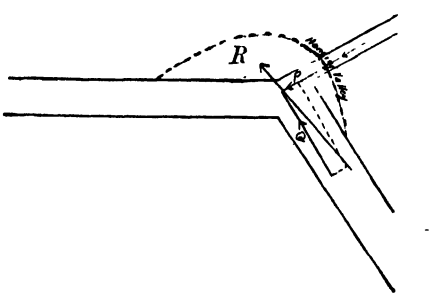
The whole valley sides also will (in the extreme case where a channel forms a whole valley) be called on to accommodate themselves to the basin profiles. Powerful under cutting action takes place with the removal of spurs and the cutting back of tributary mouths. In proportion as these tributaries are weak so will the basining action of the main stream in the constriction cause the mouths of the minor side valleys to be left perched high above the floor of the channel.

If the confluent streams be of equal strength and their axes be arranged symmetrically to that of the main stream, then the basin will be disposed symmetrically to the valley walls and the action on the high bounding valley walls will be similar [Fig. 5 (a)].

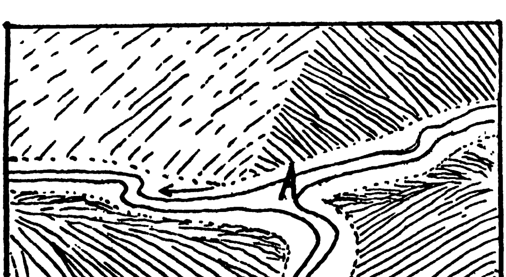
Fig. 5.



(a) Illustration of general direction of stream at a constriction formed at a canon confluence, each feeder being of equal strength and equally inclined to the main stream.

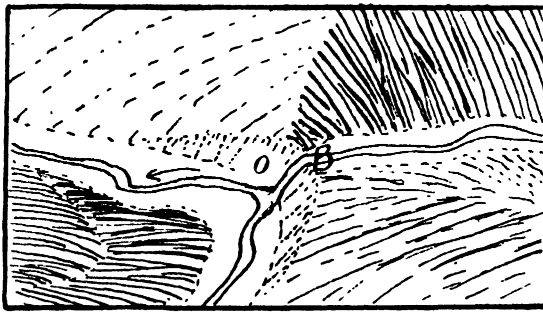


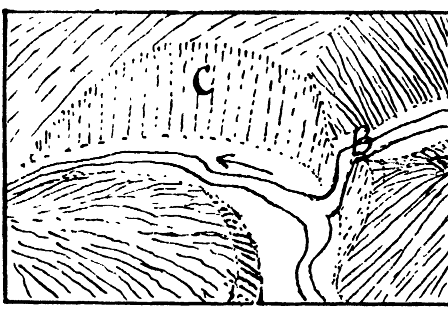
(b) Confluence of two streams of variable strength Q being greater than P. R marks the direction of greatest stream strength.



(c) Streams of unequal strength joining at accordant grades.

(d) Hanging Valley produced at *O* by later and stronger stream action. *O* indicates the location of maximum action along the cutting curve.





(e) A Hanging Valley where the location of maximum cutting action is situated down stream of the Hanging Valley lip.

If, however, the axes of the confluent streams be not symmetrically disposed to the axis of the main stream [Fig. 5 (b)] then basining and the associated heaviest under cutting of walls will be found facing the direction of heaviest stream action as at R, Fig. 5 (b). The topographic configuration will indicate which such direction will be in any where the streams occupy considerable portion of their valleys.

(2) *Corrasion on channel slopes.*—Each stream has some limiting channel slope along which it can but barely flow. Any reduction in the angular value of this slope will cause

the stream material to become stagnant if unaltered in volume. This slope will vary with all streams, being flatter in the cases of more mobile or more voluminous streams and steeper as the mobility or the volume of stream is decreased. Commencing then with this limiting slope of channel bed it is evident that any increase of such will be productive of increase of velocity.

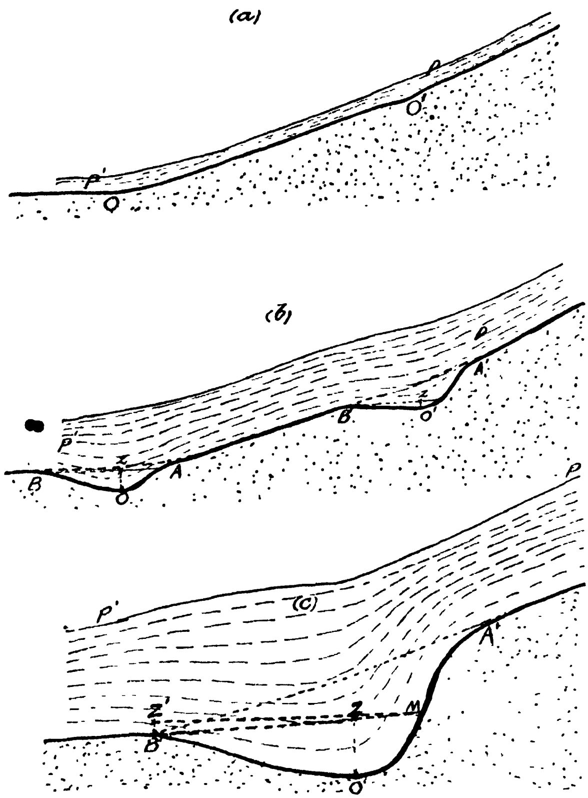
In addition to this general increase of stream velocity by steepening of the slope of the channel bed there may also be local increase of velocity arising either from channel constrictions or from variable strengths of the channel structures. At all such points stream corrasion will be much more strongly emphasised than is the increase of velocity and here excavations will tend to form in the channel base.

Now at every point on a channel declivity gravity is tending to induce a vertical motion in the sliding, rolling and flowing mass. With this motion also at any point, there is the more or less horizontal motion of the stream mass, caused by the opposition which the channel base sets up to a "free falling" motion. Consequently the path of the stream is inclined at some angle to the vertical (tendency to parabolic motion). The declivity then will not experience the total energy of the stream, and in proportion to the increase of declivity so will the channel declivity experience a less percentage of the total energy of the stream. This has nothing to do with the absolute energy expended on the declivity, but merely with the relative percentage of stream energy so expended.

But at all points where the angular value of the slope is rapidly changed from higher to lower, there the percentage of stream strength expended as corrasion rapidly increases. At such abrupt changes from declivity to flats the net result is loss of stream energy which is expressed by inten-

sified corrasion, while during the passage of declivities there is a net gain in energy to the stream.

Fig. 6.

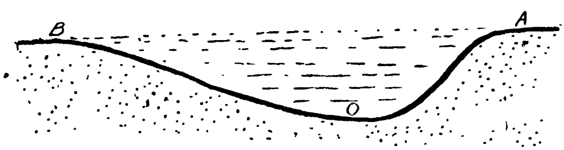


Various stages in corrasion which is locally accentuated on a channel slope.

Let O′O represent such a declivity where O′ and O represent such sudden changes of grade, Fig. 6 (a). Then the points O and O′ will furnish occasions for excavations below the general channel slope. [Every channel base furnishes good examples of such interrupted slope.] Upon the increase of stream velocity such features will be accentu-

ated as shown at A O B, A′O′B′ in Fig. 6 (b). In other words, basins or relatively reduced grades will be formed at such points. But such basins will differ in some respects from those formed below the associated base levels along channel bases of negligible slope. In the case of the basin formed wholly below the general channel slope as shown in Fig. 7, the descent of the stream mass from A to O is attended only with loss of stream energy, since the line A B is horizontal and thus gravity has here no opportunity for increasing the stream energy.

Fig. 7.



Rock basin formed wholly below associated local base levels. The profile A O B is a section along a local base level also.

In the case of the excavation on a declivity let A′O′B′, Fig. 6 (c) represent an enlargement of A′O′B′ in Fig. 6 (b). Let B′Z M represent the slope at which the stream under consideration loses its flowage characteristics, and let M Z′ be a horizontal line, Z′B′ being vertical. Then the fall A′Z′ represents the vertical distance through which the stream gains power while passing from A′ to B′. Let O′ represent the deepest point at which the stream can move the mass M O′B′ as a whole, then Z O′ represents the vertical measure of the corrasive efficiency of the stream at that point. At B′ much of its power is lost now, and it depends for its further momentum on the descent of the slope B′ A B Fig. 6 (b).

There is therefore a double action on the slope A′M O′. From A′ to M gravity will express itself in great measure as "free falling" as well as flowage, the stream strength of

course growing all the time, while from M to O′ the work is done without increase of stream strength, energy decreases rapidly, and motion is more in the nature of flowage.

The excavation above M will therefore be influenced by the form assumed by the material in homogeneous structures falling under the influence of gravity toward a central gash. This is the amphitheatre or cirque form with curve slope decreasing with depth. (For exceptional forms see Appendix).

From M to O′ the horizontal velocity is increased by flowage setting in under pressure and vertical velocity is rapidly decreased. The time factor for the whole corrasive curve A′M O′ is the same. The curve M O′ tends therefore to possess a comparatively small angular value. It will be important to remember this difference in excavation methods when considering the farther history of such basins.

B. *Subsequent history of channels and channel basins determined by increase of stream velocity.*

Several cases need to be considered here, namely:—

(i) Basins etc. in channel constrictions, the channel slope being negligible.

(ii) Basins and associated forms at channel confluences

(iii) Basin and overdeepened channel slopes.

(iv) Basins and overdeepening of channels in weak local structures.

The key to the situation here again is the knowledge that variable stream velocity, all other things being equal, produces very variable corrasive results. If the time factor has had a moderate value only, then a careful examination of the channel base and sides will furnish an epitome of the results of the variable stream velocities along that channel. Each stream considered from point to point of intake of its larger tributaries must seek to render its velocity uniform.

This is a necessity from the laws which govern streams. And the only method open thus to the gravity stream is the adjustment of its cross-sections so as to secure a flow of even strength. It is not that the stream aims at excavating below the general channel bottom and aims at steepening the channel walls in "constrictions," but merely that it is forced to express an increase of strength by locally enlarging its cross-section, because the time factor for both weaker and stronger stream action along the same channel is constant.

(i) Basins and associated forms in channel constrictions. We assume here that the channel slope is negligible and that the increase of velocity is caused by relative smallness of cross-section and not by additional volume of stream material from side sources. [The case of a channel confluence forming a constriction is dealt with later].

In Fig. 3 the curve A O is very pronounced the corrasion being powerful in the direction A O and dying away toward O. Therefore, as time progresses (the stream volume remaining constant) the basin head must recede by corrasion until such time as the stream has no strength to move its mass as a unit over the point A. When such a stage arrives, the recession of A ceases until the point B is also lowered.

When the channel cross-section is so much enlarged that there is no local increase of stream velocity at a basin head, the cessation of the formation of that basin head has arrived. At such a stage also the lower end of the basin may be already partly silted up, owing to the general enlargement of the whole cross-section of the channel upstream, thus reducing the stream velocity still further down stream along the reduced slope.

In the case of a very large stream, therefore, whose velocity has been increased by passage of a lengthy channel

constriction, the basin formed below base level or the general channel over deepening will extend along the whole of the constriction or "narrow" and gradually merge into the grade upstream, if the time factor be great enough. But it must be remembered that it was the initial basin which expressed the utmost strength of the stream at that point, and that also at a time when the heavy stream action was determined by the conditions existing which permitted relative smallness of cross-section upstream. But with the progressive enlargement of cross-section upstream, the increase of velocity became less pronounced, and the lower stream then lost its original strength, and could not move its load as a whole over the basin depths. Aggradation therefore would already have set in there: this is an important point.

(ii) Confluence of streams to form a channel constriction.

Firstly, along channel grades of negligible slope. Here the basins will recede headwards along the tributaries until the conditions favouring local increase of stream velocity cease. If several marked constrictions occur at channel confluences, and if other channel "narrows" be associated with them, then with great stream volume the conditions are favourable here for the formation of several deep basins almost or quite continuous and having "deeps" which occur at points where the increase of stream velocity is more pronounced.

Secondly, constrictions at channel confluences along channel grades of high slope. This case will be considered under the heading "Declivities."

(iii) Declivities.

The initial history of a basin formed on a channel declivity differs materially from that formed along a channel base of negligible slope.

In the stereogram Fig. 8 (a), let P P′Q‴Q″Q′Q represent a channel with a slope P P′P″P‴. Let P′Z represent the angular value of the gravity stream surface slope when at rest, then the wedge P P′Z P″P‴ represents the rock structures above the local base level at P P′.

In the case of a mobile stream, such as water, the height P″Z will not have quite the same significance as for that of a crystalline solid forced to flow only under enormous pressure. This is so because the limiting angular values of such stream slopes at rest are widely different.

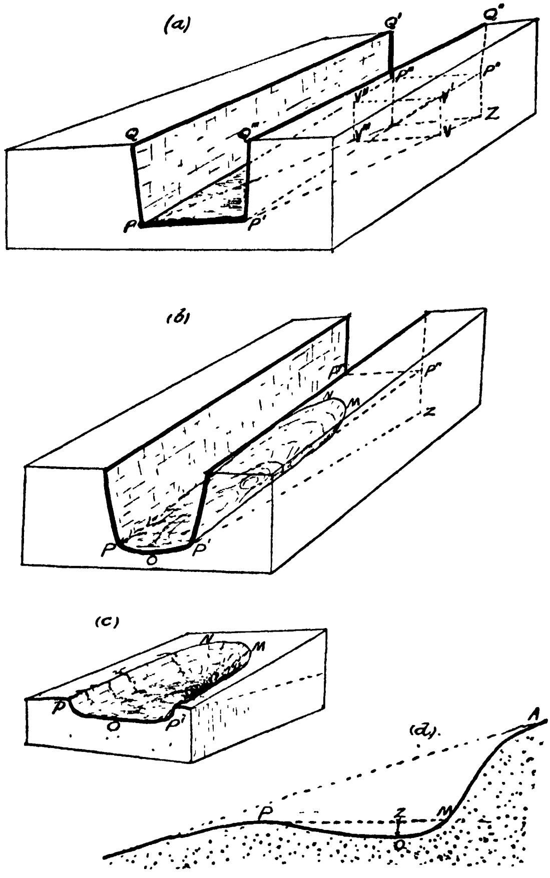
Suppose P O P′, Fig. 8 (b) to represent the transverse section of the basin which has originated on such a slope as illustrated by Fig. 6 (b) and (e). Then for reasons which have been already set out, when discussing basin formation or valley overdeepening along channel grades of negligible slope, the basin head recedes along the declivity say in some such fashion as P P′M N, Fig. 8 (b) and (c). The stream velocity is increasing (due allowance of course being made for friction) as it descends from P″ to P O P′. A basin such as P Z M O [Fig. 8 (d)] may thus originate.

Z O which marks the deepest portion of the basin then represents the vertical measure of the corrasive efficiency of the stream at the most recent points of headward recession.

The points now arise:—"Will the amount of such vertical corrasion vary? and will the basin depths below the associated local base levels become more pronounced, or will they decrease? And moreover, what will be the stream history at P′P [Fig. 8 (b) and (c)], while A M O is progressively receding, when the stream volume is supposed to be constant?"

These questions admit of ready answers. The reader will remember that the natural stream has only one oppor-

Fig. 8.



Figures illustrating some methods adopted by streams in enlarging the channel (and valley) cross-section so as finally to harmonize the stream velocities. Uniformity of stream velocity works towards uniformity of channel slope.

tunity to render its velocity more uniform, and that is by enlarging its cross-section. The method of such enlargement on negligible slopes and deep and constricted channels is by lowering the whole channel base; by excavating

basins below the associated local base levels and by great undercutting of channel walls as the stream carries its flattish floor sideways. But in the case of our stream on a declivity, such enlargement of cross-section is possible, and is more easily brought about, by cutting away the mass P P′Z P″P‴ which lies above the local base level P′P [Fig. 8 (b), than in the other case of the negligible slope where the stream had the much more difficult task of excavating below the associated base levels.

Now as the cross-sction is much enlarged the velocity of the stream is correspondingly reduced and has therefore but little opportunity for forming basins below the base level P Z M [Fig. 8 (d)] or P′Z [Fig. 8 (b)], since its power decreases in a high geometrical ratio with the decrease of stream velocity. As the amphitheatre therefore works backwards to P″Z, the whole mass, of which P′Z P″ is a longitudinal section, has been removed allowing so much greater cross-section, in which the stream may distribute its velocity. Local corrasion here then, below the line P Z, receives a decided check. In the case then of a high declivity, there would be a tendency for Z O[1] [Fig. 8 (d)] to be less emphasised than would have been expected on first thought. That is, valley ŏver deepening may here be brought about without basin formations at all.

But another point of importance here also suggests itself. The stream volume is constant, and now works in a much larger cross-section, at the same time flowing from A to M. This implies that Z O may be of decided value considered from point to point of the recession, but it implies also that the vertical measure of the stream is not now so great at the lowest basin portion as it was at the time when this

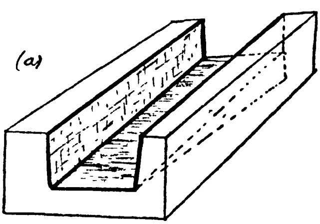
[1] Z O it will be noted is used throughout these pages as an indication of the greatest depth of a basin below the plane of the enveloping base level or base levels. It is the maximum measurement of "overdeepening."

original portion was formed. In other words the floor will tend to experience aggradation at such points down-stream.

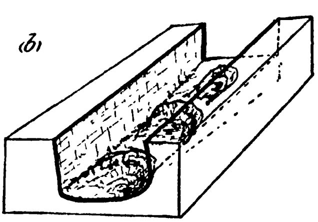
Briefly, if a stream of constant volume cut away the block P P'V V'V''V''' [Fig. 8 (a)] so as to enlarge the channel cross-section by the area V V'V''V''' then the stream velocity is measurably reduced, and as such, its capacity for basining below the plane P P'V V''' is lessened, Fig. 8 (a). A number of such recessions may thus commence simultaneously (owing to altered stream conditions) on a declivity [Fig. 6 (b)] and a channel floor may be converted into a series of "steps" with interstep "treads" (Fig. 9). This is, in fact, very common in nature. During a severe rainstorm such forms may be observed to form simultaneously on a slope, lagging behind or pursuing others.

Fig. 9.

(a)



(b)



Figures illustrating the origin of "steps" and interstep "treads" along the channel base of a stream.

Johnson (pp. 570 – 571) calls attention also to this peculiar "step" and interstep "tread" like appearances of high Alpine valleys–valleys which undoubtedly possess high channel slopes, and which have been recently visited by great ice streams. But an immediate corollary of our theorem is that all such points where velocity is increased yield similar corrasive results, and therefore a whole channel declivity may be cut up into a series of "steps" and interstep "treads" with basined floors or flattish floors diversified by shallow basins and having amphitheatrical

or cup-shaped heads. Such "steps" will pursue, or lag behind, each other according as the local stream velocity is relatively increased or retarded. In other words a channel declivity with interrupted grade may have been formed by a stream. Another constant but greater stream volume may have been superimposed and the new fluctuations of channel grade express its variable corrasive power.

(iv) Weak structures enclosed by strong ones.

Weak structures do not imply increase of stream velocity but the general appearance after corrasion in structures of varying strength is somewhat similar to that experienced by homogeneous structures when acted on by accelerated stream velocity locally, A stream thus will pick out an area of weak structures on a declivity and excavate therein a "step"—basined or not basined—with a strong "tread" at its head. The question of basin history upon reduction of stream volume will be dealt with now.

C. *History of some channel basins and "overdeepened" channels upon reduction of stream volume.*

Let us now consider the effect of reducing the stream volume under consideration. It will be well to consider two stages in this process:—

(i) A reduction to half, or a quarter, of the former volume.

(ii) A very great reduction in volume, say to the "drought" stage.

(i) Reduction to half, or a quarter, of the former volume.

The stream volume is now lessened yet its size when considered absolutely may be still very large. Pressure in this case is still so great that flowage is marked and velocity is pronounced on declivities. There are here two stages to be considered, firstly, one of channel grade readjustment, and secondly, this readjustment stage followed by a corrasive stage (with the production of forms adapted to the requirements of the new stress). That this is so

may be seen at once if we consider the "mechanics" of the question. For we have supposed the former stage to be discontinued and the latter half or quarter volume to be the measure of the utmost stream strength during the later stage. The old stream made a basin or series of basins, and generally overdeepened the channel of the weaker stream which it had superseded; it widened its course pronouncedly here and there; it cut large long embayments into the wall along side the cutting curves; it made prodigious "steps" on its channel slopes; it cut the mouths of its weaker tributary valleys so far back that the channel bases of main and tributary valleys were separated by high "steps"; it carried large volumes of debris into the "broads"; and the depth of the basins, the widths, heights and depths of the embayments along the cutting curves, as also other features of interest, expressed the absolute mechanical strength of the stream flood acting throughout a considerable period of time. Such stream volume alone was enabled to utilise the channel basin "deeps" or channel "broads" of its own making as bridges for the transport of heavy material; to urge the whole stream mass filling the basins over this bridge as a unit; and it alone could enlarge the embayments formed along the cutting curves without destroying the harmony and integrity of curvature of the channel profiles. A stream differing however slightly in volume could not make use of this grade for general corrasive purposes. Even if alteration in stream volume were related in a simple ratio to energy or work this would be a mechanical impossibility; how much more so then, when decreasing volume is associated with work suffering decrease in geometrical progression.

This is the point that may cause misapprehension unless careful note be taken of stream mechanics. For the greater the local variations in velocity are, all other things

being equal, the more variable is the local corrasion; hence, as a corollary, the more marked are the interruptions of the channel base. Now with a weaker stream flowing along the same channel, there must be less marked work of corrasion locally, hence those very spots which indicated the intense action of the flood or heavy volume stage, must now be selected for purposes of channel readjustment by the weaker stream. The first care then of the reduced stream will be both the partial filling of the great basins, and aggradation of the flattish floors, until the bridge of debris is raised sufficiently for transportation purposes; heavy deposition will also take place along the old cutting curves with partial filling of the basins there, and much aggradation action will ensue working progressively from the embayed wall toward the centre of the valley.

Let us see if this point may not be made clearer as its apprehension is vital to the proper understanding of present and recent glacial action. In Fig. 10 (a) let A O B represent a basin excavated below the old channel slope A Z B. Formerly the slope A B appears to have represented a stream channel base; then came either increased volume of a similar stream type or a much stronger stream of different type. This increase of stream strength, however produced, became gradually expressed by the growth of the basin A O B excavated below the older grade A A′B.[1] O represents the greatest depth of the upper portion of the basin, and Z O the depth is the amount of vertical cutting permissible to the stream until the point B shall have been lowered. The basin grew by headward recession and Z O progressively receded upstream. Z O is also a variable; it may have been greater or less, when at some point nearer to B, than at present. It marks the

[1] We take the case of the basin preferably as showing the extreme variability of stream corrasion locally. The case of a very flat floor produced by heavy stream volume would answer as well.

utmost strength of that stream locally as the basin or cirque head recedes. Thus when Z O marks the greatest basin depth, the stream keeps the channel head A O clean, but it may not have strength enough to utilize O B in its entirety as a bridge for the transportation of material. It must in such a case actually dump some of its debris in the neighbourhood of B or along O B.

Now suppose the stream volume to be reduced to one half or a quarter of its former volume. In such a case the stream velocity is considerably decreased, and on this account alone the measure of vertical strength of the stream will be less than Z O. But with decrease of stream volume comes a much more pronounced decrease in corrasive strength, and the vertical measure of stream strength is therefore greatly lessened.

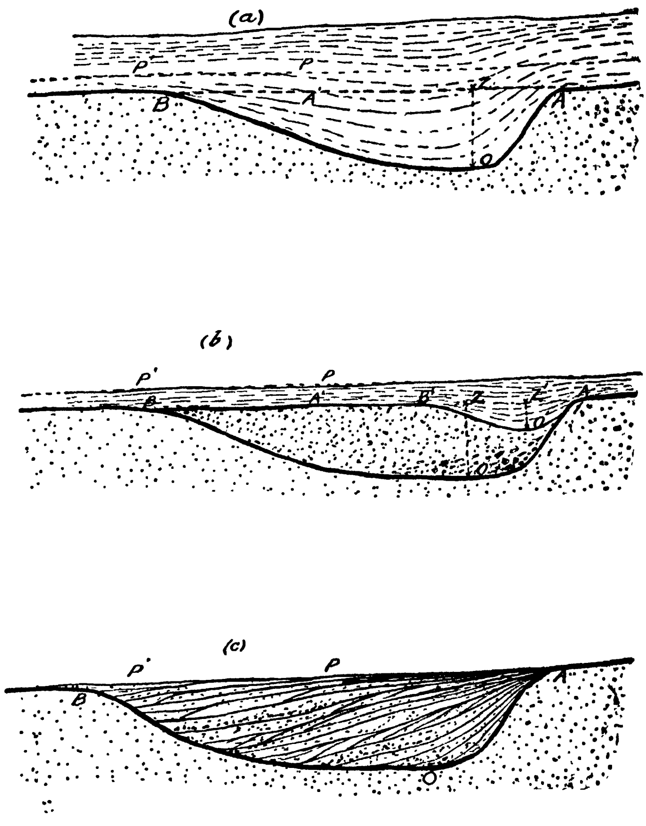
Let Z′O′ in Fig. 10 (b) represent the depth below which the reduced stream cannot cut or transport its debris as a whole. What then is the stream method here? It will be forced to drop its burden on to the basin base and sides A O B (until it can lower the point B). But the problem is also a geometrical one from the nature of the dynamic principles involved, and A Z′ will be to Z′O′ in the new basin as A Z is to Z O when all other things are equal. The new appearance will be much as in A O′B′, Fig. 10 (b).

Now under the new conditions when once the form A O′B′ is made, it will be maintained until the recession of A is again carried on, at which stage Z′O′ will progress upstream and some aggradation will ensue along O′B′; that is, if the stream volume is unaltered.

Fig. 10 (b) shows then that upon the setting in of conditions of great stream volume a great interruption of the old channel bottom A Z B was set up and a basin A O B was excavated. Upon the reduction of stream volume this became the place to be aggraded, and in proportion to the

variation in the vertical measure of stream strength so the time necessitated for such aggradation was accentuated.

Fig. 10.



Stages in the action of streams whose volume is decreasing.

(a) A O B represents the rock basin formed by a heavy stream volume (flood). Z O represents the deepest point to which such stream can corrade while the point B is stationary.

(b) Result of volume decreasing in a moderate degree. Z′O′ represents the new vertical limit of the stream's action and the mass B O A O′B′A′ shows the resultant silting following on such reduction of stream volume.

(c) Result of reducing the stream volume in great degree. Z O the variable now practically vanishes, corrasion is thereby minimised; the old cutting curves are filled with stream debris; and the rock basin A O B is silted up almost entirely.

(This is the point which apparently has been neglected hitherto in glacial discussions, for at the present day the channels formed by flood glaciers are now occupied by much smaller ice masses).

In the case of a small stream such interruptions of channel bed are of slight interest to the ordinary person, but in the case of very large streams, since the length, breadth and depth all increase in some surprisingly rapid ratio, basins may be obtained of topographic importance. Nevertheless the processes in the formation of each are alike in the main.

Subsequent stage of corrasion.—After the enforced readjustment of grades the stream will now excavate similarly situated forms through the flood debris, and inside of the old flood forms. This has been fully set forth by Gilbert for the case of water. The profiles at this stage will again be those of headward recession as distinguished from those of downstream advance by the readjustment of slope. Steep and narrow trenches will be cut into the similarly shaped and similarly situated enveloping forms. If the original flood were short lived its corrasive forms would tend to be shallow, action not having lasted long enough in which to accomplish its purpose. Should the weaker stream be long lived then time becomes an important factor, and the newer corrasion will express itself as narrower and deeper trenches developed within much broader and shallower examples. This has been discussed before when considering the path of a stream.

We say again, however, that until the traces of these older enveloping forms are either obliterated, or made subordinate features altogether upon a general view, they

are to be considered as the main expression of corrasion in the locality under consideration.

(ii) Great reduction in stream volume.

Fig. 10 (c) explains this stage. The slope A P B represented the older channel grade. A heavy stream volume succeeded and made the basin A O B. At a later period the stream volume was wonderfully reduced and Z O [Fig. 10 (a)] the vertical measure of corrasive strength as a result shrunk until it became a vanishing quantity. The stream at this stage had no strength to corrade below the profile A P B. It therefore gradually filled the basin A O B in delta fashion and dropped the heavier burden between A and O and silted up the whole portion between A and B.

Similar shrinking action occurred at the embayments of the cutting curves where the material was dumped on the outside curve, and was crowded towards the central stream portions, for the stream at any time has its lateral and longitudinal as well as its vertical measures of corrasive strength. In brief, along the "basins," the constrictions, and in the channel "broads" alike, such a stream will stagnate and fail to accomplish work for a considerable period following on the reduction of the stream volume.

D. *Action at "broads" and around obstacles.*

Having inquired into the corrasive action of streams along channel constrictions, at channel confluences, and on structures of variable strength, let us consider briefly the action of a stream upon leaving a canon "narrow" and entering a "broad."

The cross-section of the channel is here much greater and the stream velocity is thus much decreased. But the power of corrasion suffers immense decrease thereby not being related in a simple ratio to the decrease in stream velocity. The load borne along by the stream when traversing the "narrow" is now too heavy to handle in its

entirety, and the "broad" becomes in part an aggradation spot, and is utilised as a bridge for the transportation of lighter river material only. In times of heaviest volume, the stream will develop velocity sufficient for the corrasion of its base with the production of cutting curves at isolated spots, but such basin development will be weak as compared with that in the "narrows." Basins may often be developed here, however, by aggradation processes, as when the heavy rush from the "narrow" carries the material a certain distance only down the "broad" and allows of local impounding of the stream. Such "broads" and constrictions arise frequently as the result of stream action on associated weak and hard rock structures. The stream excavates a "broad" in weak structures while waiting for the channel base to be lowered in the more resistant structures downstream.

Corrasion of obstacles in channels.—Obstacles small as compared with volume of stream.—Take the case of an obstacle small as compared with the volume of the stream. The obstacle has no appreciable effect on the stream motion as the stream rises over and glides around it in taking the lines of least resistance. Gravity is always tending to impart a vertical direction to the stream flow and all other things being equal, the obstacle on its upstream aspect receives the greater part of the local abrasive action of the stream. The result is much local corrasion, and such force delivered is at the general expense of the stream momentum and energy.

But on the downstream aspect of the obstacle the case is different. For although gravity is attempting to give a vertical direction to the stream at this spot, the direction of the stream velocity as it passes over the obstacle will not allow the abrasive energy to take full effect here. So long as the stream has any velocity whatever, so long

will the stream energy experience a less percentage of loss by corrasive action in proportion as the downstream slope of the obstacle is increased. In the case of the sides of the obstacle the stream follows the lines of least resistance, and will corrade with varying degrees of strength according as these side slopes are inclined to, or away from, the stream motion. Nevertheless, although the stream may not cause much loss to a very steep downstream face by actual abrasion, yet it may strongly corrade it by sapping, by plucking, and by quarrying actions.

Briefly, the obstacle by supposition is small as compared with the stream volume. It does not, therefore, appreciably affect the velocity. The stream thus passes over the obstacle while local pressure, as flow and falling actions, tends to bend the stream toward the downstream aspect of the obstacle. Eddies and sapping action may thus be produced. The end result is a net loss to the energy of the stream.

Obstacles large as compared with the stream.—In the case of small obstacles the surface of the stream is not altered perceptibly by the presence of the obstacle and the passage of the same by the stream is attended by a slight net loss only of stream energy. In the case of the large obstacle or mass, the surface of the stream is altogether changed. The stream now is either impounded while rising over the mass or has its surface slope considerably lowered. We will neglect the case where the stream is impounded with practical loss of local energy and consider the case of a very large mass presenting but little obstruction to the stream flow on its upstream aspect and presenting a marked declivity on its downstream side.

In such case, stream motion is not seriously checked, and the basal layers accomplish strong corrasion of the upper portions of the obstacle. But on passing over the

large obstacle the surface slope of the stream is suddenly and markedly steepened, because here the flowing mass is presented in its entirety with an opportunity to rapidly take up a position much nearer the main base level, and the case is then one of accelerated velocity, in which reduction of the stream cross-section must follow as a necessity (from the fact that time is a constantly flowing quantity). The action of gravity is now to produce a constantly increasing stream velocity, and it works partly to produce free falling action and partly to produce flowage phenomena. In the extreme case where the downstream aspect is a perpendicular or overhanging wall, gravity has free play, the mass then in great measure falls over the wall, and flowage is resumed lower down. But even in this general case the constant acceleration of gravity operates all along the declivity and the heaviest action is therefore delivered at or near the foot of the declivity.

Masses which are traversed by streams and which also are very large as compared with the stream volume suffer immense loss by the corrasive action of the stream, but give added life to the stream as a whole by causing it to traverse their down stream slopes with increased velocity. On the one hand they rob the stream of power through being corraded by it; on the other hand they force it rapidly to occupy a position nearer the base level, and thus its power is increased. The algebraic sum of the activities is a net gain to the stream strength. Certain qualifying conditions should be borne in mind in this connection:—

(i) With increasing stream velocity comes greater ability to shoot over the obstacle slope before the vertical accelerant of gravity at any point has time to operate fully. (Fig. 3.)

(ii) With increasing slope the same law operates.

In the extreme case the cliff is overhanging. The stream mass falls with ever increasing velocity and accomplishes heavy corrasion at the cliff base. The cliff face itself in this case is not corraded, but is sapped from the basal attack and recedes under pressure of its own weight. But whether falling or flowing over a declivity, the qualitative effects of corrasion are similar and tend to produce similar geometrical forms.

In the case of the overhanging cliff we are no longer dealing with homogeneous structures but with lower and relatively weak structures capped by relatively strong ones. The "gravitative curve" in that case is carried up in the weak lower structures and reversed in passing from the weaker to the stronger structures. (Fig. 12 Appendix.)

Summary of "Stream" Corrasion.—It is a fact of observation that earth material will corrade live rock structures over which it is dragged. So long, then, as any stream has power to move the total load which overlies a particular point of the channel base, it is enabled to act on the underlying rocks at that point, and thus it will cut vertically into the rock structures forming its channel base and sides. Moreover the corrasive power of a stream rises in some high geometrical ratio with the increase of stream velocity, and hence at localities which are the seat of action of increased stream activity, the vertical cutting will be correspondingly pronounced. This is a fixed mechanical principle. The conditions producing such increase of velocity are to be found in areas of channel constrictions, and also on steep channel slopes; and they may be expected where great stream volume acts in conjunction with either of the two types of configuration just mentioned.

Gravity aims at causing the stream and its load to deliver a vertical blow, with the production of a more or less cylindrical cavity possessing a vertical axis, in the ideal

case the location of greatest strength being vertically under the more central portions of the stream.

The path of the stream however tends to the parabolic form. The greater the stream strength so much more deeply will it dig vertically below the local base level. Nevertheless, all other things being equal, the more swiftly it moves, just so much is there a tendency for the slope of the headward curve of the corrasive cut produced to become increasingly flat. Again, it is evident that as the stream velocity is increased, and as stream depth is increased also at the expense of stream width, so in like manner will the base of the corrasive cut below base level tend to become flattened and to become possessed of vertical walls. Its head will tend to the cirque or amphitheatre form.

Upon steep channel slopes, especially when such are associated with variable strength of structures, basins or flattish floors are likewise formed by streams when the velocity is increased. Inasmuch, however, as the removal of a declivity by cirque recession involves rapid increase of channel cross-section and thus a pronounced decrease locally of stream velocity, basins below base level will here not be so pronounced, but troughs with flattish floors, and ending upstream in "steps," will rather express their action. In this case the stream energy increases by descent of the "step" as opposed to the loss of stream energy in descending a basin. The tendency is, therefore, to produce a modification of the true "gravitative form" at its head; that is, the form produced by matter falling freely toward a central gash or cut. For a description of this important form see the Appendix.

The first paragraph of this summary suggests that all such basins formed below base level and such "steps"—of which latter the cirque appears to be but a variety—must grow by headward recession until such time as the stream

shall be unable to drag its load over the live rock structures forming these heads. Thus a whole channel constriction may be occupied by a deep basin, or several constrictions and several points of stream confluence may be joined up by one large basin as an end result of such headward recession of basins and allied forms.

This method of corrasion must hold also for material which is solid under ordinary conditions and pressures, but which is forced to flow under great pressure. With the increase of pressure comes increased mobility; this increased mobility is not related simply to corrasion, hence exceptionally large volumes of such material when flowing on steep channel slopes and through decided constrictions, will accomplish relatively great vertical and lateral corrasion.

Decrease of stream volume implies the shrinkage of the lateral, vertical and longitudinal measures of stream strength. This in turn implies readjustment of channel grades and stream incompetency at just those locations where the great volume had revealed its greatest energy. The quantitative value of such vertical and lateral corrasion could be estimated.

Part II.

Glaciers are Gravity Streams.—Is a glacier a gravity stream? Is it influenced by increase of volume, by declivities, and by channel constrictions as ordinary streams are? Is it susceptible to flow under these conditions, the mobility so gained increasing in same ratio, simple or complex, with the pressure? Does it follow the lines of least resistance or lines of quickest descent as ordinary streams do; does the "law of the cross-sections" hold in its case, or does it depend for its motion on physical conditions which differ qualitatively from those governing ordinary stream motion?

What we seek is not so much the knowledge as to the ultimate composition or texture of a glacier as information concerning its general character when in motion. It may move by rotation of its constituent granules upon each other; it may move by differential motion being set up between other sets of textural units than ice granules; this does not concern us here, for if it really be a stream, then flow may possibly be transferred from one set of textural units to another by simple readjustment of its volume (see Introduction) without alteration of its general stream characteristics. Its motion as a whole does interest us however.

Evidence of Sherzer.—According to this observer,[1] experimenters such as Main, McConnell, Koch, Mügge and others, have bent, elongated, compressed and twisted bars of ordinary ice and glacier ice without visible rupture, even when such ice has been kept continually below freezing temperature. It would appear, also, as a result of these experiments that the apparent plasticity increased with the pressure. This latter is a most important and significant feature of the case. Sherzer also as a result of careful observation, apparently demonstrates that "glacier ice is capable of showing a certain type of plasticity" (p. 130).

The writer has observed the same glaciers which Sherzer here is discussing, and his (Sherzer's) deduction as to the plastic mode of motion exhibited by glaciers appears justifiable from the evidence yielded by a study of these ice masses in the field. This conclusion, it must be remembered, was reached by Sherzer for some of the dirtiest glaciers known to science.

Chamberlin and Salisbury.—These authors[2] devote a considerable space to the discussion of glacier motion. No

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[1] W. H. Sherzer, Glaciers of the Canadian Selkirks and Rockies, Smithsonian Institution, 1907, pp. 129 - 131.

[2] Geology, Vol. I, pp. 261 - 263.

allowance is made in their discussions for the fact that the present day glaciers are the weaker, less plastic, and the dirtier representatives of glaciers which produced the channels in which they in turn do little but stagnate. [A consideration of such conditions might result in ascertaining that the textural unit of the old heavy glacier varied considerably from that of the relatively stagnant modern glacier.]

They find in glaciers, all other things being equal, something akin to the following[1]:—

1. The movement of the ice mass increases with increased depth.
2. Movement is greater on steep slopes.
3. Constrictions in channels give increased speed.
4. Enlargement of the channel cross-sections results in decrease of speed.
5. The ice flow is fastest in the neighbourhood of the centre, slower at the sides and at the base.
6. Ice flows round corners.
7. Ice is subject to other differential motions, often resulting in shearing.

The significance of these points in order appears to be as follows:—

1. With increasing pressure the textural units of the glacier ice move more freely on each other, that is, the flowage rate is increased.

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[1] "It (the glacier) works its way down the valley in a manner which in the aggregate, is similar to the movement of a stiff liquid. The likeness to a river extends to many details. Not only does the centre move faster than the sides, and the upper part faster than the bottom, as in the case of streams, but the movement is more rapid in constricted portions of the valley and slower in the broader parts" (Chamberlin and Salisbury, Geology, Vol. I, p. 236). Such a statement of motion is practically all that is needed to establish the conclusions arrived at in these papers.

2. Gravity acts freely as opportunity offers and aims at producing a cut normal to the earth's surface. With no obstacle resisting its pressure it causes a body to fall freely. Upon a declivity it expresses its power partly as flow and partly as free falling, the latter factor rising as the slope increases, for gravity always attempts an approximation to its ideal, viz.:—vertical motion.

3. In a stream, pressure as weight begets increased freedom among the lower textural units of the mass. A get-away is present; flow is thus set up and the surface slope in a downstream direction must be preserved. Where a channel narrows in, the relatively small stream cross-section here must be associated with increase of velocity. This is so both from a consideration of the volumes and a consideration of the constancy of the time factor involved. This is one of the marked features of a stream.

4. The channel "Broad" is fed from an upstream mass of less cross-section. To counterbalance this enforced increase of volume locally, the velocity must here be proportionately reduced as compared with that of the upstream feeding mass.

5. If friction were reduced to zero, it is apparent as W. D. Johnson (pp. 576 – 577) suggests,[1] that the fastest motion would be vertically beneath the centre and at the base. But in nature friction is pronounced at the base of streams, therefore the maximum rate of flow is at some distance above the base and away from the sides.

6. This is also a characteristic of streams. They must follow the lines of least resistance. At such a point the stream is influenced in a double way. Pressure from above and from the sides induces freer motion among the textural units of the glacier, the freedom varying with the pressure, and the tendency also is to fall freely under the action of

[1] See also Andrews (a) pp. 37, 38.

gravity. The stream must therefore flow round a corner as opportunity offers in seeking the lines of least resistance.

7. Shearing of rigid and partly plastic bodies is one phase of differential motion ; another phase is found in the violent eddying, the undertow, the splashes and the shore waves of such mobile masses as water.

Facts of observation gleaned in the Californian Sierras. —The observations briefly mentioned here were made in company with Dr. G. K. Gilbert and Mr. W. D. Johnson in August and September 1908, and are specially instructive in any discussion as to the analogies existent between glacial and ordinary stream action.

All of the following observations were made in areas of recent intense glaciation. The ice masses of the present day are mere glacierets. The departed ice masses evidently attained a thickness of at least from one thousand to two thousand feet, and ice polish and glacial striæ are abundant.

1. In the Evolution and San Joaquin valleys quarrying by ice had been an extremely common occurrence. Frequently the ice impact had been of such nature that a rock block had been quarried across the dominant joint structures. Ice abrasion had been set up instantly at such points, but in nearly every case the direction of the basal ice had been altered locally, the striæ on the quarried surface varying in direction with those which apparently had passed over its site just before the quarrying took place.

In proportion as the downstream slope of the hole or cavity thus produced by the quarrying approached the vertical, so in that proportion had that slope suffered less from abrasion by the downward moving mass. If its slope were very gentle downstream, then the ice striations were almost equally pronounced here as on the flat or gently reversed stoss-seit slopes.

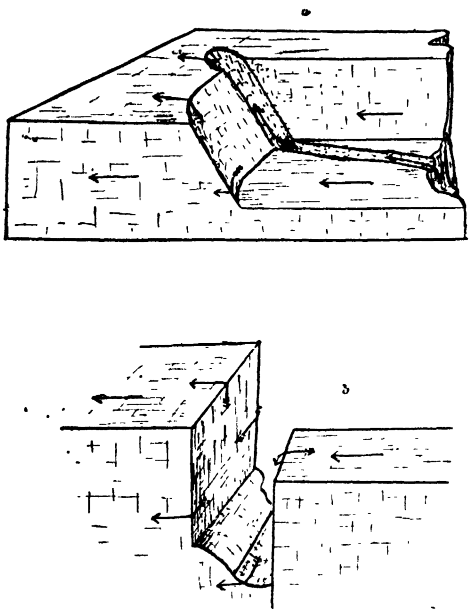
2. Moutonnees exhibited peculiar appearances; if large they appeared to be abraded on the up slope, and heavily quarried on the downslope. Actual deposition at times was observed at the feet of the steep down slopes. (This was at times due to the effect of later and less powerful glacial action.) If small they were strongly abraded on upstream slopes but in proportion as their downstream slopes were steep, such actual slopes appeared to have been protected from abrasion. Nevertheless, the downstream side had suffered by other methods of corrasion. The condition producing this steep downstream slope on small moutonnees appeared to be that of smashing and quarrying by the glacier on the downstream edge of the stoss-seit face, thus causing the lee seit to recede upstream.

3. Where glaciers had passed round large masses of rock, for example, a cliff summit presenting numerous large irregularities of surface, where the whole mass would be in the line of strong scour, and the ridge discussed would have its axis in the line of general ice flow, there the ice movements were most instructive. On a floor ending down stream against a rock face, the ice scour had produced a long deep sinuous groove along the line of least resistance to stream flow. Guided by slope to the steep rock face just described, the ice-made groove followed it clear up to the summit [Fig. 11 (a)] because horizontal escape was impossible.

On passing from one high ridge to another both of whose axes lay in the direction of main ice motion, and where the higher ridge presented a broad vertical wall to the lower upstream example, wall and ridge being separated by a deep cross fissure passing on each side to the valley depths below, there the ice grooves followed the general axial direction of the lower ridge, but on meeting the cross ditch, and opposing higher wall, they passed horizontally and

obliquely round the cliff face, as offering lines of least resistance to flow. At the same time the main glacial flow over the opposing ridge summit formed grooves following the general direction of this higher mass, Fig. 11 (b).

Fig. 11.



(a) Directions followed by ice in passing over a rock mass in the San Joaquin Valley, California.

(b) Ideal sketch illustrating action of ice in traversing two high ridges in the San Joaquin Valley. The ridges rise 1000 feet above the valley base.

4. On the San Joaquin cliffs where the rock faces are formed of dense structures and where the valley cross-sections in their lower portions are relatively small, the great walls are literally covered with huge and closely set horizontal grooves, giving rise to the appearance of the parallel grooves on a circular galvanised iron tank. Some of the grooves are as much as ten feet in depth. In each case their disposition is such as strikingly to suggest that here the glacier locally took the lines of least resistance and moulded the stream to the wall. In other cases a slight upward motion of the ice grooves was observed on

the walls as though the central ice pressure had thrust the lateral portions upwards and outwards.

5. On the shoulders of spurs standing in the way of the heavy glaciation much abrasion was noted on the upstream side, and much quarrying on the downstream side, the quarrying often producing incipient cirque forms.

In all these Sierran observations one fact stood out plainly, to wit, that the ice locally had followed the lines of least resistance; that it would not ascend a steep slope if opportunity offered at all for horizontal or less steeply inclined motion; nevertheless if no such opportunity offered it would ascend the steepest slope and even corrade such in its ascent, provided that the obstacle face was small as compared with the glacier volume, whereas on a downstream obstacle slope its abrasive action weakened in proportion to the verticality assumed by such downstream slope until in cases of actual verticality no polishing or smoothing was observed, although the ice-scratchings were strongly marked over all the associated forms.

And this is just what we should expect from a stream flowing under gravity because of the tendency to form a parabolic path. For the downstream slope of a small obstacle to experience the full stress of the glacier there must be no motion. But a stream passing over a small obstacle has a velocity, and this must be taken into consideration as well as the velocity due to gravity. This will give a direction approximating locally to the vertical in very sluggish streams, and this vertical motion is less marked in proportion to the increase of stream velocity. Hence, all other things being equal, on the downstream slope of small obstacles—slopes of which the stream motion is independent—we would expect to find abrasion less marked in proportion to the verticality of such slope. On the other hand we would expect heavy abrasion on the upstream slope.

Another significant fact noticed in connection with these Sierran observations is the occurence of almost stagnant glacierets at the heads of these deglaciated valleys. One of these small ice masses showed beautiful bands in the small ice cliff at its foot. Such a glacier must have been practically inert. Nevertheless all over the valley sides lower down were grooves and markings of such size and shapes as to suggest intense and variable motion for the former and larger glaciers. Thus increased volume of ice all other things being equal, apparently implies an increased plasticity for glaciers, and hence a great increase in their corrasive power.

Further notes on the action of a crystalline solid (ice) forced to flow under gravity.—Firstly, the topography the ice stream may start upon is a chance one. The stream may utilise and make a selective action among local structures, but so far as its origin was concerned it simply grew, as its material (snow flakes) may have fallen from the sky; by the action of gravity it became a stream, and up to this stage it had no choice of topographic or structural environment. In brief, the excessively mobile stream could not elect to act on incoherent structures only, such, for example, as sand, any more than the excessively large stream of sluggish habit could elect to flow over the strongest structures only. An important point is thus disclosed. Since the structures are practically the same over which the mobile and sluggish streams work, there may come a time when the limit between stream and structural strengths may be exceeded, and then the impact of the enormous stream mass (glacier) will overcome the strength even of important channel structures, the while the very mobile stream will corrade mainly by abrasion.

Now, in the case of a solid forced thus to flow, both its falling action over ledges and its rolling or sliding down of

declivities are working in the same corrasive direction as flow action. This follows from an apprehension of the mechanics involved. Both are due primarily to the same vertical force; in both cases the bodies act on similar declivities; both follow the lines of least resistance, the paths of quickest descent. One delivers a more sudden blow; the other delivers a less sudden blow in a similarly situated spot.

(a) *Heavy volume (Flood) stage.*—As the volume increases the glacier may swell over the valley or canon rims and partly drown the higher topography. The few exposed rocks now can shower very little debris on to the more solid surface layers of the stream. Thus the stream at this high stage is not heavily penalised by a superficial burden. Moreover as the study of mechanics has shown us, its speed in such case is much greater than at the time when the stream mass was possessed of less volume; its textural units now glide more rapidly on each other; the units become smaller with increased volume, and the surface also is cleaner by reason of this quicker action in reaching stream destination. Of course, in this case, it picks up a greater bottom load, but since its accelerated velocity is not related in a simple ratio to its increase of transporting power, its ability to handle its bottom load increases in geometrical ratio to its increase in velocity by volume. It can also (as we have shown in Part I of this Series) drop its bottom load or override it as occasion arises.

Corrasive effects.—Now, what will be the general stream action as it swells over the rims of the stream-developed valleys? These valleys, by whatever other stream action determined primarily, mark the action of gravity in forcing stream material to take the lines of least resistance, the lines of quickest descent, to the local base levels. As such

the peculiar geometrical forms produced by corrasion during the earlier period of stream transportation of debris are those which will be more closely followed by any immediately succeeding stream, however variable in texture and composition. Therefore, at this early stage, however high the stream rises, however much it disports itself above the valley rims, its most intense action must lie along the lower portions of the old stream developed channels which it found ready to hand.[1] It may wear these barriers away and modify its drainage later, but while it occupies that topography, while those older stream developed valleys remain, the new stream will exert its greatest corrasive force along the deeper, steeper and more contracted points of such valleys. And the more it rises above the valley rims, and the deeper and more confined those valleys or canons become, and the steeper the channel slopes, the more strongly will the stream work along the lower portions of the canons. Pressure and friction are opposed however; the reflection of bottom and side velocities has to be accounted for and the actual maximum velocity of the ice will be found not at the base but at a varying height above it.[2] The greatest corrasive strength is however basal as we have shown in Part I.

At the summits, mighty as its volume is, the flood glacier accomplishes but relatively little corrasion. There are not the well defined channels here; there are not the marked declivities to act on; there are not the valley constrictions to induce increase of velocity. In other words the lines of least resistance lie along the bases of the valleys which are sunken deeply into the plateau, and along the latter alone is seen the greatest increase of stream corrasive power. Great as the flood volume may be away from the channel proper, it acts somewhat similarly to the backwaters

[1] Andrews (a) pp 37 – 39. [2] Johnson, p. 576.

of an ordinary river flood. It lies stagnant, rises higher and higher, ever ready to cause devastation, but lacking the chance to do so except at extremely localised spots.

And again, even along the valley bases proper, aggradation may be going on hand in hand with corrasion. As the increased power of corrasion in channel narrows and other favourable spots allows the mighty stream to overcome the strength of the rock structures; to burst off large fragments; to wedge out slabs along or across joint systems; to abrade the scars so made with larger or smaller stream debris, so on reaching a lower valley "broad" the velocity is much checked; work is disproportionately decreased, and dropping out of the largest blocks occurs from time to time.

Thus very large basins may be associated with debris strewn "broads" containing islands or hummocks rising above the general level. This point will receive further attention later on.

Another interesting point here follows as a corollary. Seeing that pressure increases flow, all other things being equal, and that accelerated flow is attended by a wonderfully increased power of corrasion, it follows that the same glacial thickness which we have been considering—capable of accomplishing such corrasive wonders when the cross-sections are so reduced in strong walled canons many thousands of feet deep—could not accomplish any such marked differential corrasion in areas of senile topography. The load for unit surface is just the same, but gravitative stress has here no lines of deep descent, no marked valley constrictions, no such profound depths to follow. In a word, the action is more even and the channel bases are much less interrupted.

Before considering the next point, namely, the effect of a decreasing glaciation, we might note at the height of the

flood, in areas of greatly reduced cross-section, particularly where the canons are of great depth, that from frictional considerations, differential velocity would be correspondingly marked. This would give rise to very pronounced varying movement of the upper layers. Yet evidence of internal work as this is, and consequent loss to corrasion, nevertheless, no one would consider for an instant that the energy had actually decreased. On the contrary, despite the loss thus sustained, the energy as a whole would rise enormously. It is simply the algebraic sum of two sets of actions in which the result is gain to the stream. Every day one sees analogies to this in ordinary streams, in "rivers gone mad," or in the great "waves of translation" determined by onshore gales.

(b) *Reduction in glacial volume (Drought) stage.*—Several factors here all conspire to reduce the efficiency of the stream as a corrader.

1. The reduction of volume will give the stream material opportunity frequently to return to its solid state in part or almost as a whole. The observer who has had opportunity to watch the same class of stream material making its channel profile during highest flood, may have difficulty in recognising the flood and drought phases of such a stream as belonging to similar types of stream material.

2. A much greater amount of the topography now dominates it. Its volume is definitely lessened; the hills now stand high above it and shower their debris upon it. In proportion as the former action has been fierce, so will the decrease in volume in the early drought stages be correspondingly noted for its incapacity for work.

3. Then comes the greater factor of decreased velocity. The glacier has undergone great reduction in volume this means great loss of speed, and this, in turn, indicates relative stagnation of corrasive action. [This is exactly the case with present day glaciers; they are drought glaciers.]

The presence of a mobile body such as water may now ease its path downwards; the yielding and rending of its mass under gravitative stress may help it down declivities; it may actually break in avalanche form over "steps" or amphitheatre heads, but any work of corrasion accomplished in this way will be in the direction of the production of the "gravitative form," that peculiar geometrical form which in the extreme case is a cylindrical cavity leading from the surface of the earth to its centre.

The glacier now appears incompetent as a corrader; it seems scarcely able to flow; its textural units reveal very slight relative motion, the units themselves doubtless change in character even; its most halting phases are shown where the greatest work of the flood glacier was accomplished [Fig. 10 (c), Part I]; it creeps haltingly over the masses of debris; it lies stagnant in the basins of its own flood making; it is impounded by the debris; its former relatively clean and strongly moving surface is now a sluggish and much jointed mass; it is dominated by the old cliffs which express the flood corrasion; it is the sport of avalanches; it becomes a dumping ground for the cliff talus; its sluggishness allows of its almost complete burial in places under debris; and the more the talus smothers its front the more stagnant and incompetent it becomes. And to emphasize the matter, at just those places where the stream had been so strong, at those places does the weak shrunken stream receive more debris. This has been pointed out by Tarr, for a vertical cliff, determined by undercutting and freshly exposed to air by diminution of stream volume, must seek to find its atmospheric slope of repose and thus give rise to much cliff debris.

Yet even this stream at last, either by itself or by aid from other more mobile, or from more dense streams, assumes a general corrasive aspect, after having adjusted

its channel grade to its own strength. But until that stage arrives it will slowly corrade the declivities, and with the material so gained and the material otherwise transported. will slowly build up the channel irregularities.

(c) *Terms "Flood" and "Drought."*—While on the subject of flood and drought action, it may be well to remove any misconception that might arise from the use of the term "Flood." To the popular mind the word flood is associated with an ephemeral heavy rush of water or lava, something in which the time factor is very insignificant. In these pages a flood is supposed to have reference to stream volume, without regard being had necessarily to the time factor. A flood may last but the fraction of an hour, or it may be drawn out for many thousands of years. A period of flood action may also be taken to mean a summation of the action of several or of many floods of varying strength. All other things being equal, an excessively mobile stream will—in nature—have a flood stage period of very much less duration than that of a very viscous or of a stream but slightly plastic.

In these pages, that which is known as a Glacial Period, or an Ice Age, is considered as an Ice Flood. Just as the periods of great volume in ordinary stream history are known as their flood periods, so the periods of great ice volume in the history of recent glaciation are taken as ice floods. The slight fluctuations in the volumes of modern glaciers, the slight movements of recession and advance witnessed to-day, are analogous to the tiny fluctuations of volume for ordinary streams during their low level stages. But in the two flood types the time factor varies greatly, in the one the flood water quickly subsides, whereas in the other the period of great volume may last many thousands of years.

In the flood and drought stages of streams we have a contrasting of the time and volume factors whose values are not simply related. Increase of volume means increase of velocity and therefore increase of corrasive power in geometrical progression, while increase of time simply means a simple increase of the corrasive work accomplished.

When in previous reports [Andrews (a) and (b)] the belief has been declared that, in nature, stream channel forms are the result of flood action and that the interflood stream is a hopeless incompetent, the meaning was simply that the time factor during the interflood period of stream corrasion has been altogether outmatched by the rapid increase of corrasive power attendant on increase of volume.

Let us see if light may not be thrown on this distinction between absolute and comparative corrasive work of streams by a comparison with ordinary business methods. For example, a penny is in reality a very useful coin, with it a large daily newspaper may be purchased, or a long ride taken on a street car. Notwithstanding the decided value of such a coin no business firm would entertain the idea of exacting the odd penny from a customer whose purchase amounted, say, to £100 6s. 1d. Even for a purchase of £5 value, the seller often gives some small article in as not affecting the general amount. Again no contractor offers a house for sale at £859 10s. 1d. or £999 19s. 11¾d. In fact he takes his unit of price as not less than £5. He may offer a dwelling for £725 or £1,000, but not for £726 or £998.

In a similar sense we say that the flood stream does all the work of corrasion, and that the normal or drought stream is a hopeless incompetent, for while yet such enfeebled stream action has not, apparently, in slight degree even, affected the grand enveloping profiles, a flood stage again sets in and carries on its own profile making.

And this we think is the point which, properly apprehended, would explain most of the difficulties experienced in the study of glacial problems. But of this more anon.

Summary of flood and drought stream action.—The vertical strength of stream corrasion is not related in a simple manner to its increase in velocity, hence a channel bed approximately uninterrupted at one period, would if visited by long heavy flood action, become diversified by huge interruptions, such features being accentuated in regions of youthful topography. Conversely, immediately after a great reduction in stream velocity the locations at which the drought-stricken stream reveals its maximum incompetence would be those of maximum interruption of channel bases.

Special application of stream principles to glaciers.—In the present chapter an endeavour has been made to explain the significance of the forms found in regions of former intense glaciation, simply from a knowledge of the mechanics of streams. The deductions are based on the belief that in the regions about to be considered, several strong glacial floods acted along canons and other valley types originating in ordinary stream action. This assumption of such pre-glacial valley formation is necessitated by the knowledge that glaciated and non-glaciated topographies exist in close association along the valleys of California (for example, that of the Merced below Yosemite), of Western New Zealand, of Australia, and other localities where glaciated profiles upstream gradually pass into typically non-glaciated profiles lower downstream, and where the non-glaciated country situated immediately downstream of the traces of glaciation is in such a stage of development as to strongly suggest that the work of glaciation appears to have been confined to profound local modification of the valley contours, without alteration of the main pre-glacial valley directions.

(a) *Rock basins.*—These will be expected mostly in Alpine regions—localities of profound canons with steep channel slopes and of pronounced canon constrictions. The glacier depends for its energy on declivities and volume. The rock basin evidences a dissipation of stream energy. The declivity gives added energy while the rock basin is an attempt to readjust matters in the opposite direction. So long as the peculiar conditions last, which permit of increased velocity, so must the rock basin heads recede and the declivities be cut away. In homogeneous rock structures each will possess the cirque head, the one as a basin sunken below the local base level, the other as a series of small or mighty "steps" in the valley. Local variations in rock structure, or in valley cross-sections on declivities will give rise to basins with heads above base-level, and the recession of such will give rise to "steps" with intervening "treads," the "treads" tending to hold basins of corrasion according to the degree of valley contraction existing at those spots.

All other things being equal, basins will have depths proportioned to the strengths of the travelling glaciers. The deeper and more confined the channels, and the more pronounced the swarming of the Ice Sheet over the channel rims, the smaller also the cross-sections are locally, so much deeper and longer will be the basins formed. The basin must be deepened and lengthened so long as the vertical motion is not expended, or so long as the glacier can transport its load either across any cross-section, or along the basin base, as a whole. Therefore a glacier which has decided velocity and depth, and which is confined within high resistant walls (so as to prevent lateral escape) will corrade its base to a much lower point than the associated or neighbouring water streams. Fiord basin depths are not related merely to the buoyancy of ice in water, but

mainly to the energy determined by the topographic configuration immediately upstream, and there is apparently no necessity to call in land subsidence or faulting to account for their depths when a more simple explanation of the phenomena (such as that of stream formation) is at hand.

(b) *Hanging valleys.*—All other things being equal, the channel of the main stream is cut down to a lower point than that of the channel base of any tributary stream. This arises from the fact that stream corrasion increases in some high geometrical ratio with the stream velocity (function of volume). The more senile the topography the less pronounced this relative over deepening of the main channel, while the stage of the youthful dissection of plateaus is attended by more pronounced over deepening of the main channel. The mighty "Hanging Valley" of Alpine regions is simply a corollary to the main proposition of the great over deepening by ice of the main canon. The mere phenomenon, however, of the "Hanging Valley" is to be seen along any stream channel.

The greater the volume of the stream and the greater its velocity gained either by motion down declivities or through valley constrictions, so much more emphasized will be the over deepening of the main valley as compared with that of the tributary valley. Therefore, under a condition of small stream volume we have the base of the tributary channel hung above that of the main channel, but upon the increase of stream volume along the same channel the tributary channel base is still further "hung up" with respect to that of the main channel.

Only in profound and constricted canons is the great velocity obtainable which is necessary for the formation of the great hanging valleys common to all Alpine regions. It is the canon walls which allow of the great depth and confinement of the ice stream which then responds by greatly

increasing its velocity. This action in turn produces the interruptions in the channel base which are expressed most decidedly by basining. Such features are accentuated in proportion as the time factor becomes important enough to allow the flood glaciers to adjust the channel grade to their strength. The disposition of the channel constrictions or slopes or the arrangement of the confluent canons, when forming a constriction at the point of confluence, will determine which side of the main channel will be selected for special attack by undercutting. [Fig. 5 (a), (b), (d), (e).]

This is the analogy with the cutting curve of water and of other streams. The seeming difficulty arising from a comparison of the profiles formed by the various stream types will be considered later. It may be mentioned in passing, that the difficulty is only apparent and not real, and arises probably from a comparison of the action of one stream type, when in the drought stage, with that of another type when the latter is in the flood stage.

But to return from this slight digression. If one channel contains the larger and possibly more rapid glacier then by composing the strength and direction of the larger with that of the other but less important feeding stream, the direction of maximum glacial action will be found to lie along the direction of the more important feeder rather than along that of the less important one, (Fig. 5) and if this confluence forms a channel constriction at the point of junction, then the maximum stream action will form a cutting curve in the constriction, and such cutting curve will practically face the direction of motion of the stronger glacial tributary. This will be the side also where basin depths—if present at all—will be more pronounced and where lateral cutting will be most emphasised.

Now if a relatively small glacier discharges into the main channel along this cutting curve its mouth will be made

to retreat along its old course. If the tributary glacier be small and not constricted along its lower course, while the main glacier is very large and suffers marked constriction at this locality, then undercutting and valley over deepening on the cutting curve will be marked and the retreat upstream of the mouth of the tributary will be correspondingly marked. In other words, all other conditions being equal, the weaker the tributary stream action is in such areas the more pronounced will be the hanging valleys. This has been well shown by Davis.

The following indicates the conditions necessary for the maximum development of Hanging Valleys.

If the valley constriction be symmetrically arranged to a central axis, then Hanging Valley phenomena may be expected to be fairly equally developed along both sides of the valley. The development of Hanging Valleys shows the stage of land dissection arrived at in such localities during pre-glacial time. For it is evident that valleys hung high up can exist only in perfection when profound channel depths, fairly high channel slopes, resistant wall structures, valley constrictions well marked, and immense stream volume all conspire to work together. In other words such geographical forms cause great local increase of stream velocity, and this involves a still greater local variation in the corrasive strength of streams. This results in marked interruptions of the channel bases, two expressions of which are the deep basins below base level and the basined or non-basined "tread" under a heavy declivity, and the immediate corollary of which is the hanging nature of minor tributary valleys.

But this condition of things could only arise during the early dissection of a high block of land, because a moment's consideration will show that a stage such as the very late maturity of dissection would afford only moderate oppor-

tunities for marked increase of velocity locally and so would result in relatively small examples of hanging valleys.

In the case of the old age or senile stage of land dissection, there cannot be :—

1. High mountains to produce deep channels.
2. Canon constrictions.
3. Steep channel slopes.

We may suppose the depth of ice traversing such localities to be as great as that which has worked over Alpine or Fiord regions, but even then we would not get the same marked interruptions of channel bases. In such a case there would be no opportunity for striking local increase of ice velocity to arise, with this increase of velocity again to be compounded with a geometrical rise in corrasive power; therefore there could be no such great corrasive results in these topographies like those we find in the Norwegian regions, where hanging valleys discharge over heights of thousands of feet into the main channels.[1]

It would not help us in this consideration were we to demand the quantitative values of the ice corrasion in each case. All we are concerned with at present is the comparative result. The quantitative problem will be solved later. Thus if it be demonstrated that an ice sheet can corrade a plain or an area which has been dissected to the senile stage—even if that corrasion be apparently feeble only—then from mechanical principles it may be demonstrated that in Fiord and Alpine regions a similar ice sheet would produce local corrasion on such a stupendous scale as to suggest to the untrained observer the action of two unlike agencies in the production of the typical forms of the two areas.

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[1] This idea of youthful glacial Alpine dissection has been especially insisted on by Davis.

Conversely if the quantitative value of heavy ice corrasion in Alpine regions be known, then corrasion of senile topography by similar ice volumes will be found to be but relatively slight.

(c) "*Steps*" *and* "*Interstep Treads.*"—It is a fact of common observation that the main Alpine valleys possess huge "steps" rising one above the other with heads more or less cup-shaped. By some investigators[1] these are considered as Hanging Valleys in the main channel. Tributary streams also exhibit this feature. They originate as basins on declivities and by headward recession they form "steps" with "interstep treads" along the channel (See Figs. 8 and 9, Part I). Ordinary stream channels are full of such forms on steep channel slopes. The "treads" appear to be basined in proportion as the local valley cross-section has favoured increase of stream velocity, or as heterogeneous structures have favoured variable corrasion. The initial nips, which by recession give rise to the "steps," were determined by conditions favouring local increase of velocity on a declivity or by the differential strength of the structures forming the slope. Headward recession of some "steps" will progress more rapidly than that of others. Thus some will appear to pursue, some meanwhile lagging behind others.

(d) *Cirques.*—In geographical discussions the term "cirque" has been generally restricted to the amphitheatres situated along present or recent glacial divides. As will be shown presently, the valley "step" is closely related to the cirque, but the cirque proper is a more simple form than the "step." A glance at a cirque and the valley of which it is the head shows that the cirque proper is not merely a phase of corrasion peculiar to the start of a glacier, but rather that it marks the method of headward

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[1] Garwood.

recession in glacial valley formation, the temporary headward limit of growth. Otherwise the glacier—or other stream—occupying the valley head must be possessed of sufficient strength to form the cirque and its continuation below as a valley by a gouging action from behind—an operation mechanically impossible for a glacier.

Let us assume then that the cirque has been formed, and that the gathering ground is small. Consider now the action of the corrading glacier under conditions of undiminished volume. The snow banks pass downward into ice, and as the glacier forms in the cirque, the tendency is to produce increase of velocity with the progress of the ice stream down the cirque declivity (thalweg), nevertheless the actual percentage of the total glacial energy that is expended as corrasion decreases as the steepness of the cirque slope increases. This arises from a consideration of the paths of the ice particles. It is evident also, other things being equal, that the maximum stream force that is expended as corrasion lies at the most abrupt changes of channel slope. In the case of the cirque such point will lie at its base. The tendency here then is to produce a rock basin, as described in Part I of this Series. See also Fig. 6 (c). If, however, there is a rapid increase in the valley cross-section (thus reducing the glacial velocity) during this corrasion at the cirque base and sides, then the basin dies away and passes upstream into a more or less gentle slope. This has been considered also in Part I.

Above the basal portion of the cirque there is a dual action.

Firstly, there is the important sapping action attending the formation of the basin or other form located at the point where the glacier expends its greatest energy. This sapping action it is which tends to give the characteristic profiles to the typical cirque; or an approximation to the

gravitative form (an amphitheatre) induced when earth materials fall evenly towards a vertical gash in the earth's crust.

Secondly, there is the corrasive action of the glacier as it descends the slope of sapping.

These basal and central actions then determine a double slope for the cirque proper [Fig. 8 (d), Part I).

A third but more gentle slope is doubtless formed frequently by ordinary sapping methods at still higher levels, where the snow mass is too small in volume to accomplish much corrasion.

This is of course on the assumption that the ice volume has not diminished seriously during the recession of the glacial valley head. On the other hand we have undoubted proof that in all Alpine valleys known to us, the present glaciers are but the dwarfed representatives of ice streams which have but recently disappeared. So recent has been this disappearance that the very scratches and "polish" they left on the valley sides and bottoms have not yet been obliterated by later erosive activities. Evidently then the cirques as we see them to-day have been fashioned by the recent ice streams, if by glaciers at all. Let us see then whether any trustworthy information as to the formation of cirques could be gained by an examination of the action of the present glaciers in their cirques. Now the first action of a dwarfed stream is to readjust its channel grade so as to recommence the work of corrasion along a channel adjusted to its own strength (See Part I of this Series). In the particular case under consideration the first stage in this readjustment process therefore is aggradation at the spots where the greatest local variation of ice velocity had produced the most marked interruptions of channel grades. The dwarfed glacier therefore will commence dumping debris on the base of the cirque; the high walls of the

cirque will shower debris on to the glacier, and the glacier itself will tend to stagnate in the basal portions of the valley, possibly even preserving a banded appearance to its very front. Around the upper portion of the glacier the ice will now not be moulded to the wall, owing to this new relation existing between the diminished glacier and the wall which had been adjusted to the strength of the older and much larger glacier. Cracks curving sympathetically with the wall of the cirque now indicate this ill-adjustment of ice and old channel form, this straining of the dwarfed stream mass to fit itself to the too generous porportions of the containing amphitheatre. In the earlier stages when the channel profiles were formed by the stream, there were few or no crevasses and no bergschrunds, for then the depth and strength of the ice were so adjusted as to make it a true stream, whose surface was continuous over any interruptions of channel base other than great ice falls, [that is, where valley heads were receding along valley floors]. But now during the dwarfed or drought stage the surface of the glacier is not deep and large enough so as to give the plasticity requisite to maintain a continuous surface while traversing the monstrous interruptions of grade formed during the earlier or flood stage. Nevertheless the ice is forced to accommodate itself to the irregularities of the channel base, since all streams must follow the thalweg; it is therefore in a state of perpetual tension and the crevasses express its attempts at adjustment of glacial surface to basal movement. Fill up the cirque and associated valley to the old ice level and we have a stream with surface harmoniously continuous as a result of perfect adjustment of glacial strength to channel profiles. Such a glacier would be practically free from crevasses. When this readjustment process is complete, the diminished ice stream will commence excavating smaller cirques and valleys within the older examples. The newer and smaller

examples of cirques will have steeper heads than the older enveloping forms. This is from a consideration of the path of a stream particle.

It would thus appear that the bergschrund as we see it, is an effect rather than a cause of the modern cirque. In the conditions obtaining in the more vigorous ice cutting period just departed, it is extremely improbable that a crevasse situated vertically above the present bergschrund could have penetrated to the glacial depths necessary to have reached bedrock at the present change of slope between cirque base and headward slope. The bergschrund and its sympathetically curving schrunds appear to be a result of tension in a crystalline solid which under earlier conditions of greater volume has been a much more perfect stream mass and which never excavated its channel base to depths greater than those above which it could maintain its stream characteristics. Under the present conditions a get-away is of course found down the old thalweg, and the ice mass yields partly by flow and partly by cracking, since it no longer possesses volume enough to secure continuity of surface.

But even if this be so, it does not in the least discount the value of Johnson's (pp. 573–576) report on cirques. That report has been invaluable in glacial studies, inasmuch as it has furnished us with the key to the formation of cirques, namely, by headward recession; to the fact of "steps" and "treads" occurring along a glacial valley floor; and to the relatively heavy action at the bases of glaciers. The point neglected in his note is apparently the variable quantitative values (and their significance) of the corrasive action of present and recent glaciers.

Relation between Cirques and Valley "Steps."—The cirque arises as a result of headward recession, but in this process the channel base will doubtless be cut up into a

series of "steps" and "treads," as has been already discussed for the general stream in Part I of this Series.

This introduces the subject of the similarities and dissimilarities of form which should be expected to exist between cirques proper and "steps." The "step" is really a cirque form, but it involves a more complex corrasive action than does the cirque proper. The typical cirque approximates more to the ideal gravitative form—that form produced by earth material falling freely towards a vertical gash made in the earth's crust—because the form is produced typically at or near glacial divides. The "step" is a result of all the processes at work in the formation of the cirque, but involves also the passage of the stream (glacier) over the lip of the cirque.

The enormous quarrying action thus exercised completely modifies the typical cirque form, namely, by squaring off the profiles of the upper portions of the "gravitative" form. Magnificent examples of such quarrying action and consequent destruction of the typical cirque form occur in the Yosemite, as at Nevada and Vernal Falls. These will receive due attention later.

The cirque under a col is an example of a "step" or modification of the typical cirque.

(e) *Action in "Broads."*—Where the flood glaciers, for any reason, left a canon defile or entered a part of the valley possessing a much greater cross-section, the velocity of the ice suffered a check. This involved the dropping out of a part of the ground moraine some distance in advance of the canon mouth.

If now the ice should suddenly vanish and water streams should occupy the old glacial channels, they would here form huge lakes dammed by moraines, which in many cases would pass into rock basins higher upstream. The partial

drainage of such lakes would reveal their rock basin origin higher upstream in, and just below, the constriction, while their morainic origin lower down would also be seen.

(f) *Moraines.*—These would, by analogy with gravity streams, be almost wanting in the canon constrictions, and the greater the stream volume and the greater the velocity the less opportunity for any material to exist in, or near, the defile.

In a pronounced "broad" the law of the cross-sections is emphasised, there will be a great decrease in velocity; corrasion will be at a minimum and partial falling out of the ground moraine may be experienced even at this flood stage.

Thus the same stream may produce mighty fiord basins at one spot, while at another spot along its channel, it may not only be incompetent to continue the deep basin formation, but even be unable to remove hillocks or incise itself into lowlying plains. Moraine dumping may even be in progress hereabouts.

But in every case a glance at the land surface, all other things being equal, would suggest the location of minimum and maximum action, and furthermore, not only the location of such maximum and minimum glacial corrasion, but would also suggest the quantitative variations of such corrasive action. This is probably the explanation for the differential action of glaciers as found by Gilbert in Alaska and cited by Fairchild.

Annette Island and the lowland around Sitka apparently lie in valley "broads," possibly even at or beyond valley mouths. For example, they may represent terraces of marine erosion. As such the glaciers here must follow the law of the increased cross-sections which give great general slackening of velocity. This is associated with geometrical

decrease in corrasive power. At such points one could not expect to find pronounced interruptions of channel slope.

Similarly the apparent failure of the ice sheet to corrade the Lockport limestone of the Niagara escarpment, while it deepened the Cayuga and Seneca Lake Basins may be explained. (See Part III of this Series.)

The greater the volume and velocity of the Ice Sheet, the more pronounced will be the increase of velocity in the basal ice when passing from the broad flaring valley into the canon with much reduced cross-sectional area. But over the senile, or old age topography, there is little or no opportunity for differential velocity to be set up locally in the Ice Sheet. In proportion then as the topography approaches the plain stage, the more will the ice act as a static body.

(g) *Drumlins.*—Another very important point for consideration is that of the further history of the morainic debris during and after the readjustment of channel grades attendant on decrease of stream volume.

As the ice sheet passes over regions which have been dissected to the senile stage, its transporting and corrasive power will experience but little variation in individual southern zones equidistant from the ideal glacial centre. In the flood stage then, the ice tends to carry its ground moraine in even manner over these regions of gentle relief. Even at the flood stage, however, as the ice sheet enters on to areas of gentle relief after leaving hilly country, it will be characterised by some aggradation. But with a decrease in the ice volume, its power of transportation of the infra-glacial load will be greatly decreased. The great ground moraines of the flood stages are now too large to be carried along bodily with evenly distributed corrasion of the area of gentle relief, such as we have been considering. The reduced ice sheet therefore at this stage seeks

to readjust its channel grade and to establish itself again as a corrasive agent by gradually ridding itself of the surplusage of infra-glacial load. The stagnant morainic mass now presents a consequent surface to the reduced ice sheet. Its basal portions will therefore find the lines of quickest descent, and the lines of least resistance in the ground moraine, and a relatively more rapid basal ice motion will ensue locally with differential corrasion of the ground moraine. Channels will be cut into it, and as these channels are deepened the reduced mass will again attack the earth structures, not by moving the ground moraine as a whole over the fresh rock, this being a mechanical impossibility in the stage under consideration, but by excavating trenches in the morainic mass and accomplishing corrasion by local concentration of force at the bases of such trenches; [the same force spread out over the whole area would produce only negligible results. All streams act alike in this connection, whether they represent extremely mobile, partially plastic or partially solid types].

Thus in one place the reduced ice sheet attacks its moraine, in another it overrides it, aggrades it, or moulds it into long lenticular masses. These peculiar lenticular forms are partly the result of corrasion of the ground moraine, but are often in great measure a result of accretions brought from regions higher upstream. Thus the ground moraine belonging to the flood period may be steadily incised in one place, and its material gradually deposited on the lee seit of an obstacle downstream. Overlapping accretions drawn out axially will thus originate. All sorts of conditions must be expected.

But the aim of the reduced ice mass is to move the moraines out of its way and to set up corrasion of the rock structures afresh, and if the time factor be greatly increased, it will succeed in its aim and commence to substitute

similar lenticular masses down stream derived from its own corrasive products upstream.

In this way some drumlin occurrences may possibly be explained. They may exist by reason of a smaller re-advance, or by a waning stage, of the ice floods (Ice Sheets). Drumlins characteristically mark decadent, or relatively weak ice action. In proportion to the length of time occupied by this weaker stage, will the drumlins so formed dwindle in height and decrease in number. The re-advance of one of the larger ice sheets in all its greatness—the time factor being of measurable or appreciable duration and no movements of land subsidence intervening—would clear away the present numerous forms and substitute for them several large and gently arching morainic masses.

It does not necessarily follow that drumlins have originated in this manner, but if we grant the existence of a recent ice flood with its characteristic ground moraine, then it does follow that the early action of a succeeding decadent or weaker ice sheet will be in the nature of channel readjustment, and this must result in the production of various channels with inter-channel drumlin forms. Any consideration of the peculiar relation existing between stream velocity and stream energy will show this to be evident:—the stream volume decreases; the transportation power is greatly lowered; the burden falls out in great measure; the stream overrides it; its irregularities of ground moraine slope furnish opportunity for local acceleration of stream velocity; distributaries are formed; corrasion is emphasised here; gradually the mass is cut up and finally moved away.

Part III.

Applications of the Ice Flood Hypothesis.

1. The Californian Sierras.—We may consider two classes of valleys common to these ranges, namely, any of the higher valleys such as Bloody Canon, Rock Creek or the upper San Joaquin tributaries, as illustrating one class, and any of the Yosemite valley types for the other. The following observations were made in company with Dr. G. K. Gilbert and Mr. Willard D. Johnson during the late summer of 1908. The following notes will not clash with the work of these geologists in California. Brief reference here is made only of such facts as are pertinent to the discussion of the "Ice Flood Hypothesis."

Preliminary.—The higher Sierran summits apparently represent remnants of an old surface. Beneath this a "valley in valley" appearance is found, the upper valley floors being wide while the younger and lower valleys are of the "profound canon" type.

(a) *Rock Creek Canon and San Joaquin Basin.*—Several facts stand out prominently upon even a casual study of these valleys. The valleys are steep-sided, often of great depth, and they are characterised by an absence of overlapping spurs. Blunt or truncated spurs at times present huge facets to the valleys. The floors, when considered generally, are flat and broad, but show minute irregularities of detail, frequently presenting a partially moutonneed and a partially quarried appearance. The floor is frequently interrupted by huge "steps" with intervening "treads" on heavy declivities, and these possess modified cirque forms at their heads. Each "interstep tread" may possess one lake or a series of lakes or rock basins dotting its surface. These rock basins most frequently characterise the upper parts of the valley floors, while lower down stream, where the much heavier water volume occurs, the lake basins are

generally represented by meadows through which the valley stream meanders. (See also Johnson quoted in literature.)

The well developed meadows in the valley "narrows" or constrictions are associated characteristically with high and steep opposing walls not set widely apart. These walls may be from 1,000 to 2,500 feet in height, and they reveal the action of one dominant agency in the formation of their present peculiar profiles. Above the steep walls another set of similar profiles may often be seen but of less steepness. Strong horizontal groovings occur in the valley constrictions especially on massive wall buttresses or on projections near the channel base. These grooves often parallel each other, and are as much as from six to ten feet in depth. Heavy undercutting occurs on the cliffs of a "narrow" when facing the direction of heaviest ice motion during the recent glacial period or periods. Hanging valleys occur here also. The main and tributary valley "steps" approximate to the cirque or amphitheatre shape and the valley heads themselves are represented by magnificent cirques. The "meadows" observed in the pronounced valley "broads" are associated with large moraines.

Another common feature is the existence of small cirque-like forms on the down-stream aspect of salients and high valley shoulders. Quarrying has occurred here, while strong abrasion characterises the upstream aspect. (This quarrying and abrasion is also noticeable on the down-stream and upstream aspects respectively of valley "steps"). Scratching and polishing by ice characterise the waning action of the glaciers.

Steep sided canons are commonly enveloped by somewhat similarly shaped and similarly situated forms. This gives rise to "valley in valley" (or "canon in canon") types terminated headwards by "cirque in cirque" forms. The older enveloping cirques have flatter profiles than the

smaller enclosed forms. This phenomenon was also noticed by the writer in British Columbia.

A very common feature of these steep, deep and broad-floored upper canons is the existence of a line, or series of lines, which may be seen to be strongly marked along the lower portion of the valley sides. The lines are approximately horizontal and in detail they appear to consist of small benches associated with lines of cliff erosion. Below a bench or erosion line of this kind the valley slopes generally become less regular than those above the erosion lines. These lines are very pronounced along channels of steep slope and in valley constrictions, while they fade away in valley "broads," where lines and terraces of moraines are found instead of the lines of erosion (*e.g.*, at Rock Canon). Frequently also one may see a line of such erosion extending completely along the side of the main valley constriction and being joined at accordant slope by a similar line descending a side valley wall. This line also forms the upper limit of the small cirque forms which lie within the larger and older amphitheatres or cirques. The line of erosion commences with a steep descent, which it maintains around the cirque and then the cirque form being passed it makes a more gentle descent, such declining slope, however, being proportioned to the steepness of the channel floor.

These slight benches appear also to be fairly evenly laden with moraine-like debris, while upon this in turn are scattered talus cones, derived from the weathered material of the steep upper slopes. In conclusion it may be mentioned that these canons which possess such decided evidences of former strong glacial action have now only tiny inactive glaciers at their heads—glaciers preserving a banded appearance from head to foot.

Significance of observations in the Sierras.—The higher summits of the Sierras appear to represent residuals of an

extensive peneplain. Lawson[1] refers this dismantled upland to the upper surface of a large batholith which has been stripped of its cover of sediments. The fact, however, that this dismantled peneplain surface occurs indifferently in both intruded sediments and intrusive granites must be accounted for. In this old surface, ordinary streams appear to have developed broad valley floors now uplifted to form plateau surfaces (see also Lawson, pp. 315 – 328). Especially well is this latter feature to be seen in the neighbourhood of Evolution Valley where the wide upland valley surfaces apparently are, or rather were, continuous with the wide upland valley levels of the plateaus drained by the Lower Merced, the latter almost certainly being due to the long continued action of ordinary streams. Later came a period of stream revival and the high plateau surfaces were deeply trenched by valleys. In some spots canon cutting may be seen to be due to a double period of stream revival.

After this period of canon-cutting came several ice visitations. The earliest period of which we have certain knowledge appears to have been one of strong glacial action. (A still earlier and important ice period is suggested by the peculiar profiles of the topography[2] which have been obliterated in part by the later ice masses. Of this however, we have no certain information). It was productive of long and steep-walled trenches within the more rounded forms of the older topography. [The trenches which occur in valley constrictions have spurless walls, cliff bases in alignment, and huge cirque-like heads.] Large local depressions and interruptions occurred in the channel bases, and the heads of these were caused to recede by the combined action of abrasion, quarrying and sapping until the valley floors were cut up into a series of gigantic "steps"—either high or low—with correspondingly large

[1] Lawson, A. C., pp. 300, 301. [2] Gilbert, Systematic Asymmetry.

intervening "treads,"[1] such "treads" generally possessing a flattened or even basined floor. Afterwards came recession of the ice and then apparently two later but much smaller readvances.

Taking their history together, they seem to have been productive partly of corrasion and partly of aggradation. Along the main wide valleys which possess marked declivities they appear to have formed small glacial canons by recession. The latter terminate in cirques enveloped by the older forms. Frequently two glacial canons may now be observed trenching an old or single glacial floor. (The Upper Evolution Valley for example).

Along the spurless and evenly sloping sides of the valleys formed by the previous ice flood, the reduced glaciers formed a long line of erosion, the line so made corresponding with the surface limits of the glacier. Side valleys having steep declivities along "narrows" also show the erosion lines well. These are the "schrund lines" mentioned by Gilbert (Systematic Asymmetry, p. 582).

A similar end result may be seen along the margins of fairly rapid water streams, when confined between soft banks. The strong central current causes an undulatory motion to be set up towards the sides, where a wave of translation is set up, resulting in the formation of a bench and a line of erosion. To Professor R. A. Daly the writer is indebted for an explanation of the moraine-like material which covers these benches, and the still later talus cones over them in turn. When the Glacial Period was waning snow banks still clung to the benches and became laden with debris, with the final disappearance of these snow banks the debris was left, and talus formed thereon in turn.

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[1] Many of the present "steps" and "treads" are the result of the later ice visitations.

These lines of glacial erosion were not observed in a valley "broad," such as one finds in the middle or lower portion of Rock Creek Canon. On the contrary, one would look here for aggradation, since the diminished stream could only corrade comparatively slightly, even on the declivities of the "narrows." Moreover evidence of heavy and continuous morainic deposition is actually here abundant, the moraines ever closing in on the central channel in terrace form as the glaciers diminished in volume. Such rapid decrease in the measure of lateral corrasive strength for the waning glaciers is admirably shown in Rock Creek Canon. As diminution in volume progressed, quarrying grew ever weaker, and the once powerful action of the glaciers appears to have resolved itself into the scratching, and, finally into the smooth polishing only of rock surfaces.

Then came the present stage of ice drought. The glacial volumes have shrunken so much that their weight now can barely induce ice flow. The resulting stagnancy is due in great measure to the flat channel bottoms which had been produced by the previous ice floods. Precipitation probably went on as heretofore, but little ice was formed, the stream now being of relatively mobile material. Therefore re-adjustment of channel grades ensued, and such re-adjustment of grades is still going on. It is this re-adjustment phase which has caused difficulty in grasping the significance of the phenomena of glaciation here, as elsewhere. Nevertheless, from mechanical principles it is evident that aggradation during the decadent phases of stream action will be at just those points where, on the hypothesis of valley over deepening by ice, that corrasion of valley floors and sides would have been expected to occur. Thus in valley "broads" and on cutting curves determined by the ice floods, the waning stage of glaciation should be marked by moraine deposition, the "laterals" approaching the centre in terrace form as the glacier shrinks in size.

On the Ice Flood hypothesis the deep rock basins and the lakes impounded by moraines should be filled with alluvium by the dying glaciers and by the ever increasing water action. And this condition of things it is which obtains there at present. From the steep valley sides and along the main channel itself debris is being carried to build out alluvial fans from the lake heads and sides into the basins. At an early stage the finer silt will have filled up the deepest basin hollows, even those which occur in the upper valley rock basins; while lower downstream, owing to greatly increased water volume and gathering grounds for debris, the rock basin will have been completely alluviated, and converted into a meadow traversed by a meandering stream. Thus at the present time in the Sierras, it would be impossible to say, by merely sounding the lakes just where the deepest points of the rock basins were originally located. From the high vantage point of the summit of Mount Darwin the writer has noted the wonderful silting up action which has taken place even in the Evolution Valley lakes, which from the sides of the rock basins themselves appear to be free from silt.

This being so, it might be asked how we know that the recent glacier floods have corraded most deeply along cutting curves and how we know such to be similarly situated to the deepest points of cutting curves formed by other stream flood action, seeing that no lake nor fiord basin is known to day, that is not silted up partially, or that does not possess an alluviated head.

The case is an easy one. The geometry of the "gravitative curve" is simple, and when the greater portion of the profiles remain intact, the remainder can be fairly easily restored, for from the mechanics of stream action we know the peculiar basin types to be expected. If thus we find a profound canon whose opposing walls are not set far apart

and which possess almost vertical slopes; furthermore whose side streams cascade or fall into the main stream, the valley profiles being such as to show marked undercutting at points facing the direction followed by the strongest portion of the stream, but nevertheless possessing a floor occupied by a winding stream, then we simply continue the visible profiles downwards after the manner of those known to be produced by streams, and the meadow now concealing the lower rock profiles may be confidently expected to represent the readjustment of channel slope over an old rock basin floor, shallow or deep, which originated in the action of a strong glacier. The meadow with meandering stream occupying the "tread" of a valley "step" may not hide so deep a rock basin as that formed in a valley constriction. The reason for this has been given earlier.

This meadow stage it is towards which all the Fiord and Alpine Lake basins are progressing, but the stronger the old ice floods have been, the longer will be the period of channel readjustment before water and ice can recommence their general work of corrasion.

(b) *Yosemite Valley.*—This canon is about seven miles in length, and is bordered by very steep walls, about 3,000 feet in height. The lower end of the valley proper is the narrower portion and is enclosed by the steepest walls, that of El Capitan being almost vertical and more than 3,000 feet above the valley. The floor is a gigantic meadow occupying the whole length of the valley, and varying from a half to three-quarters of a mile in width. Upstream from El Capitan the walls are almost continuous, forming a spurless valley; a very slight distance below El Capitan, however, the meadow floor disappears, the gorge becomes rather V-shaped, and under Inspiration Point the cliffs have shrunken to 1,500 or 1,700 feet in height, besides

lacking the steepness of the walls farther upstream. From Inspiration Point the stream has a very steep channel slope to El Portal, eleven miles below El Capitan. In this distance the valley floor has fallen from 3,950 feet to 1,850 only above sea level. At this spot only extremely faint signs of ice action are apparent in the form of incipient facetting or truncation of the lower valley-spur points. Around El Portal the general impression gained is that of a great upland valley level sunken well into an old peneplain, the wide upland valley itself being well dissected by great "canon in canon" formations, the inner canons presenting a marked overlapping of spurs.

But to return to Yosemite proper. The great chasm commences in the confluence of three streams, namely, the Tenaya, the Merced and the Illilouette. The Tenaya has a meadow base and sheer walls like Yosemite along its lower course, but very early recedes on a steep declivity, and is mainly V-shaped in cross-section. The Merced channel base rapidly rises, especially by the two valley "steps" of the Nevada and Vernal Falls. The Illilouette is a comparatively weak stream and discharges into the Merced channel over an enormous cliff. Just below the confluence of these rivers the weak Yosemite stream is picked up after discharging itself over a double cliff some 2,600 feet in height.

There appears to be evidence of several ice flood visitations in the Yosemite locality, but notice of one only is here made. It is that of an ice volume which only really commenced its work owing to the smallness of the time factor involved. Whether it marks a second Period of Ice advance or the waning stage of a flood only, is immaterial to our purpose. In either case temporary adjustment of channels marked the weakening phase and then later came corrasion adjusted to the strength of the younger stream.

From Mounts Dana and Lyell, and the Merced headwaters, this younger ice mass started. Its upper limits may be seen to be above the 12,000 feet level on the highest peaks. Flowing down the Tuolumne Meadows its bulk passed to the north by way of the Tuolumne Canon to Hetch Hetchy, but quite a considerable overflow passed along the Tenaya Basin with a spilling over also into the Merced drainage by way of Cathedral Peak. The heavier ice stream appears to have descended the Tenaya. At Cathedral and Echo Peaks the flood level had dropped to 10,500 feet, while just above Lake Tenaya it stood at just under 10,000 feet. Still falling rapidly, its mass passed by Clouds' Rest, leaving that peak as a nunatak. (At an earlier stage this peak was apparently buried by the ice, but that is a story less certainly decipherable, and in any case is not necessary to our purpose).

Half Dome appears to have been an island in this younger flood at the confluence of the Merced and Tenaya glaciers. An ice fall took place in the surface of the glacier here, and Glacier Point was not nearly reached by the ice mass. Down stream a fairly level surface was maintained, the thickness of the ice in the main valley being about 2,000 feet. Below this point the increase of the valley cross-section induced a marked weakening of corrasive power, while at the same time the steep channel bed urged the glacier rapidly into much warmer regions and brought about its rapid dissipation.

As high up as the 6,000, and even the 6,500 feet contour, the cross-section of the main valley appears to be less than the sum of the cross-sections of its three confluents. The channel slopes of the feeders are also very steep. These facts imply both great relative velocity for the glacier and corrasive work increased in geometrical ratio to such acceleration. A basin associated with undercutting of the

valley sides was thus formed at the conflence of the Tenaya and Merced Glaciers. The comparatively weak Illilouette was undercut and hung well up over the Merced Valley. A still more pronounced canon constriction or "narrow" occurred at El Capitan. Just in front of this and the Cathedral Spires a basin was formed. This basin was then carried upstream by headward recession along a gently rising grade. During the recessional movement lateral action with great sapping between the 6,000 and 7,000 feet levels was very pronounced, especially in the more decided "narrows" and along the cutting curves. The associated forms of El Capitan, the Cathedral Spires, and Bridal Veil Falls, originated in the relatively rapid motion of the glacier caused by the canon contraction at this point. Glacier Point and Yosemite Falls faced either resultant or reflected ice thrusts and they thus formed cutting curves. The whole valley may be considered as a pronounced canon constriction, but contraction of the valley walls is more accentuated in some places than in others. Both the Yosemite and Bridal Veil Falls are splendid examples of the removal of the lower portions of weak tributary channels possessing high grades.

As the basin which was formed at Inspiration Point and El Capitan grew by headward recession until it was connected with the basin or flat formed at the Tenaya and Merced junction, the latter basin also retreated along the steep declivities of both these tributaries. The steep channel slopes possessed at this stage by the lower Tenaya and Merced gave their glaciers wonderfully increased power locally. Thus each ice stream commenced heavy quarrying operations. Strong structural planes were made use of, and an immense V-shaped notch was made in the Tenaya Channel, and the two steps of the Nevada and Vernal Falls in the case of the Merced. The time factor,

however, failed before the work of recession got beyond the initial stages along the channels of these confluents. At the summit of the Nevada Falls for the Merced, and just below Tenaya Lake for the Tenaya valley, we see the junction of the two glacial types, namely, the more mature upstream phase and the upper limit of the vigorous youthful recession.

Had the time factor been increased, the strong quarrying phase just described would have continued until the upper Tenaya and Merced channels had become profound canons of the Yosemite type. For example, with increased time well shaped steps connecting the upper and lower valleys would have been produced, the latter having flat floors almost to the feet of the "steps."

Below Inspiration Point the general cross-section of the valley increases, and the channel slope is very great. The glacier became ineffective as a corrader below El Portal, and merely dumped moraine masses in its neighbourhood.

There may be an apparent difficulty in associating this decadence of glacial corrasion with the descent of a steep channel slope. In these pages steep slopes have been supposed to imply great increase of velocity. Nevertheless in a locality situated far below the snow line and to which the ice has been permitted to come only by reason of its great volume, then any long and steep channel declivity occurring below this level must result in glacial dissipation, because of the necessarily rapid increase of temperature.

Subsequently came a much weaker stage of glaciation, but this seems to have had little effect on the Yosemite Valley itself beyond dumping moraines in the old channel which had been practically free from debris. These then appear to be some of the main points in the history of Yosemite as one sees it to-day. Among others, brief

mention may be made of the domes, the moraines, and the readjustment of channel grades.

(a′) *Channel-grade readjustment.*—After the modification of the preglacial Yosemite canon by an ice stream a period of weaker glaciation ensued. Moraines were deposited below El Capitan, and these tended to fill the basin formed by earlier recessional erosion. Then came the present ice drought period, during which the diminished glaciers have practically assumed the inefficient stage of crystalline solids in the Californian Sierras.

The precipitation which formerly went to the alimentation of glaciers now goes off as water, and in readjusting the old ice flood grade to its own strength the water stream has filled the Yosemite Lake basin almost entirely, burying the moraines in the process.

(b′) *Moraines.*—A particularly fine group of moraines occurs along the trail from the Tuolumne Meadows to Yosemite by way of the little Yosemite. Under Clouds' Rest they lie above the 8,000 feet level, while under the Half Dome they occur about the 7,000 feet level. The moraines lie in an old cutting curve of the Merced glacier during a glacial flood, the form of the cutting curve being very decided. Upon the decrease in volume of the ice this old cutting curve became at once a "glacial slack," and moraines were dumped on the outer edges of the curve as the measure of lateral strength for the glacier diminished. Thus with continued decrease of ice volume, the cutting curve was filled by lateral moraines which paralleled each other and crowded towards the Little Yosemite canon. At the same time the old steep cliffs of Clouds' Rest and the Half Dome on the Little Yosemite side became smoothed down to steep dome shapes.

(c′) *Domes.*—As a general rule, dome shaped masses of rock in the Yosemite present a steep face to the profound

canons, and a more rounded appearance to the broader valleys. Thus half dome presents a vertical face to the profound canon of the Tenaya, and shows a more gentle slope to the moraines of the Merced. Similarly for the domes of the Little Yosemite. Watkin's Dome has a steep face in the Tenaya; El Capitan Dome gives place a little below its summit to a vertical face in the Yosemite. The domes of Yosemite, as they stand, appear to be products of exfoliation, but from a general study of the valleys leading from Mount Dana to Yosemite, they appear to have stood in causal relation to the action of earlier and larger ice floods before exfoliation repeated their older outlines. Thus the great domes appear to be roche moutonnées, which during a later stage of valley glaciation have been sapped on their canon aspects and have given rise to the steep faces of which Half Dome is an example.

2. **Milford Sound (South-western New Zealand.)**—The fiord is some twelve miles in length and originates in the confluence of two profound canons, the Arthur and Cleddau Valleys. The walls rise about 5,000 feet out of the fiord and are composed of strong crystalline schists and granitic rock types. A large tributary enters five miles below the head of the fiord. The narrowest portion of the main valley is situated near the entrance and is confined between two walls, almost vertical, the southern one being 5,600 feet, and the northern one about 5,000 feet high. Thence they rise in places less steeply to the 9,000 feet level. The width of the canon "narrow" between these two walls is a mile and a quarter.

On the northern wall occurs a splendid example of a hanging valley, while about fifty yards from its point of discharge into the Sound the salt water is 1,500 feet deep. The northern wall is steeper than the southern, and possesses some remarkable examples of Hanging Valleys

This wall also faces the more important tributary stream, namely, the Arthur. Deltas encroach on the head waters of the Sound. The tributary canons retreat on slightly rising grades and are characterised by very high and well aligned walls devoid of spurs, and which dominate wide valley floors. Here also steep cliff slopes pass above into a less steeply inclined series of slopes. The same great quarrying action with the formation of V-shaped bottoms as occur at Yosemite, are noticeable along some of the tributary valleys of Milford.

Significance.—The wonderful amount of precipitation along this coastal strip[1] coupled with the steep channel slopes and the canon constrictions produced glacial pressures of great strength. At the constriction formed at the Arthur and Cleddau confluence, a basin was formed which retreated up the feeding canons, but without possessing much depth. Lower down stream than the channel constriction formed by the Arthur and Cleddau confluences, one may observe the influence of the large Harrison Cove tributary [Andrews (a) Fig. 6], and the still more marked constriction associated with the great height of the walls at Mitre and White Peaks. Here then a deep basin was formed, which in time, by headward recession, became connected with the basin at the fiord head. During the recession marked undercutting with the production of Hanging Valleys was effected. The northern wall was especially selected for attack, owing to the set towards it of the stronger glacial motion. Moreover, owing to the inability of the glacier to find relief laterally from its enormous pressure, the basal ice was held to its work of vertical corrasion. Had the fiord walls been but 1,000 feet in height much lateral escape would have ensued, but held

[1] The precipitation in this region to-day varies from 150 to 250 inches per annum.

in a narrow canon a mile deep the immense glacier could only have its mobility increased, and the basins were therefore deepened still more, while the channel cross-section was being enlarged so as to allow of the harmonising of velocities. Therefore, because a glacier must corrade vertically above a point until it is unable to move its mass as a whole along its bed over that point, the enormous depths and flattish floors of Milford Sound basin were produced.

3. The Finger Lake Region of New York.—Tarr[1] and Lincoln[2] both understood the relation existing between the various lake basins of this district and the corrasive action of the recent Ice Sheets. In these pages the Finger Lake Region is selected, therefore, simply as an illustration of the "Ice Flood Hypothesis."

In the locality under consideration the general direction followed by the ice sheet was from north to south. A range of hills lay right athwart its course. The ice in its passage swept over the range and left large morainic deposits upon the crests in its decadent stage. The lake basins lie at the feet of the hills and occur on the northerly aspect of the range, that is, they lie in the deeper tracks used by the basal ice in climbing the range. It may be mentioned in passing that these lakes possess straight sides, hanging valleys, and other characters common to Alpine lake basins.

By some observers[3] the excavation of these lake basins by ice action is denied, because of their peculiar situation with respect to the general southerly movement of the ice sheet. The important point to remember in this connection is the fact that the ice sheet swept right over the range, that is, it maintained itself as a stream over a channel obstacle. Had it failed to scale the range it would here

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[1] Tarr, see Literature. [2] Lincoln, see Literature.

[3] Fairchild, Herman Le Roy—"Ice Erosion Theory a Fallacy" and references.

have been impounded and have lost its stream characteristics. Inasmuch however, as it preserved its stream character over the summit of the range we must seek for an explanation of its movement in the mechanics of the general stream. The case is not that of a brooklet which has filled a great basin and proceeds to trickle over at the opposite end, but rather that of an immense stream which meets an obstacle lying across the channel bed and surmounts it easily. In this case it is evident that the basal layers do not lie inert while the upper ones are sheared over them[1] but that they are forced to flow over the summit with only a lesser degree of strength than are the upper layers. Of course the basal stream layers will not ascend the upstream aspect of the obstacle so quickly as they might descend the slope, nevertheless a great percentage of the stream energy is translated into corrasion during this surmounting of an obstacle (see note on Obstacles in Part I of this Series).

Again the general corrasive effect on the upstream aspect of an obstacle may not be pronounced if that portion of the obstacle present a broad face of even slope to the ascending stream, but if definite channels exist in the upstream slope the local increase of velocity, with consequent local concentration of energy, will occur along these channels.

In the case under consideration, the ice sheet met an opposing range which was trenched with stream channels discharging northwards. As the ice sheet surmounted the range its basal layers were forced to ascend the old stream-developed channels. Towards their heads the channels were somewhat constricted. The deepest portions of the moving ice mass were vertically above the channels also,

[1] Such an inert stage may arise, however, during a waning glacial stage, when the ice moves along a grade which has been adjusted to the strength only of the flood stream.

and from the combination of these two facts, viz.:—channel constriction and maximum depth, the corrasive force of the ice sheet was relatively great at such points. In ascending the range the stream lost much of its energy, hence the corrasion weakened during the ascent, whereas on a great descent in a channel constriction the stream would gain in energy and would corrade more powerfully during its progress downstream than upstream.

In the first case the energy receives no increase, and motion and corrasion are rapidly robbing the stream of its energy (*e.g.* the Finger Lake region). In the second case stream energy is increasing by the descent of the range, and although corrasion is accomplished at the expense of the stream action nevertheless the result is a net gain in energy for the stream (*e.g.* the New Zealand, Norwegian, Alpine and Alaskan rock basins and associated forms).

4. The Hudson River at New York.—The main facts of observation appear to be as follows:—The Hudson River occupies a valley deeply sunken into the surrounding New York plain, its sides being almost straight and spurless, while its base lies far below sea-level. The surrounding plain has been strongly scoured by an ice sheet, abundant evidence of which action is supplied by the presence of the roches moutonnées to be seen everywhere around New York.

From a consideration of the principles of stream action it is evident that if the velocity of a stream has a decided value over an area of negligible slope, then along any youthful channel sunken into this area of gentle relief the velocity of the stream will be much increased as compared with its velocity when traversing the extra-channel (or flood-plain) area. This has been shown to be true for the general stream in Part I of this Series. It is simply an example of material being acted on by a constant vertical

force. The lines of least resistance are followed. In this case the lines of least resistance followed by the stream as a whole are those of quickest descent.

But the fact must not be lost sight of that the ability of a stream to corrade its channel structures is related in a highly increasing ratio to increase of stream velocity. Therefore if an ice sheet has been enabled to scour the New York plain as efficiently as it appears to have done, then it follows that the Hudson River channel, sunken into this plain, has been subjected to a much more powerful ice action. But this would result both in the great deepening of the channel and the more or less complete removal of spurs with the production of steep and straight valley sides.

5. St. Lawrence River at Quebec.—This case is similar to that just discussed for the Hudson at New York.

6. England, Wales, and Scotland.—*Snowdon (North Wales)*[1]—The general topographic features of North Wales as seen during a visit to Snowdon viâ Rhyl are :—

(i) An old surface represented now by isolated peaks and ridges of which Snowdon is an example.

(ii) A broad upland valley or younger peneplain due to the action of ordinary streams and occurring at heights apparently from 1,000 to 2,000 feet above sea-level. This is the peneplain referred to by Davis.

(iii) A series of broad mature valleys developed in the old upland valley level. These younger valleys are of the "valley in valley" type and represent periods of river revival consequent on land elevation.

(iv) A younger plain of marine (?) erosion and now elevated to form a land block of which the Isle of Anglesey is an example.

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[1] For a much fuller account of the glaciation and general topography of this locality see Davis, W. M., quoted under literature.

(v) Still younger valley cutting.

(vi) Ice visitation with the formation of *cwms*, *cribs*, facetted spurs, hanging valleys and lake basins.

There appear to have been at least two ice visitations of importance in the locality of Snowdon. The older and more important one buried the shoulders of the mountain in the vicinity of the Crib Goch. The moutonneed appearance of these shoulders is well seen during a walk from Snowdon down the cwm (cirque) under the summit to the Llanberis Pass. A "schrund line"[1] appears to exist on a shoulder to the left of the track. At a later date a smaller ice stream occupied the lower portions of the valleys. The well defined moutonnees and ice scratched rock masses mark the upward limits of this later ice visitation. In the valley constriction near the head of the Llanberis Lake, the mountain spurs may be observed to have been torn away,[2] while steep and rugged cliff slopes or wide spur facets have been left in their place. At the foot of the old steep channel slope of pre-glacial age the long Llanberis Lake occurs. This was evidently made by slow headward recession of the ice fall from an initial basin formed lower downstream. The lake is in just such a position, and is of such a shape as to suggest formation by a stream (See Part I of this Series). With the exception of one of ice, no other stream large or strong enough to excavate such a rock basin in recent times appears to have visited this locality.

In association with the valley over deepening or lake basin formation, one may see numerous examples of hanging valleys and facetted spurs. At the valley heads magnificent cwms (cirques) may be seen. These cwms, for example, the one under the Snowdon hut and down which the track winds to Llanberis Pass, are evidently definite

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[1] Gilbert, G. K., (a) p. 582. [2] See also Davis, (a) pp. 338 - 339.

thalwegs themselves, and they pass downstream into steep channel slopes interrupted by large "steps" which possess basins on the "treads."

England (The Pennines and the Lake District).—The Midland Railway in its passage from Carlisle to Kirkby Stephen follows the valley of the Eden or Esk. For some distance it skirts the bank of a young valley, thence it rises into an older and broader valley of the same stream. Still farther into the range this valley is left in turn and a third older and enveloping valley is ascended. The "valley in valley" forms here traversed represent repeated stream revivals in later Tertiary time. The upper valley has all the characteristics of a deglaciated trough. Its sides are generally devoid of spurs, and in section it is apparently U-shaped. It heads in a broad upland valley or immature peneplain, due to ordinary stream development. Above this, however, may be seen the remnants of an old and dismantled surface which survives in the fairly even-topped peaks and ridges rising out of the old upland valley level.

Both the upland valley level and the lower canons or valleys appear to have been strongly modified by ice scour. The later valleys sunken in the upland valley level, however, are those which apparently possess the most characteristic forms belonging to all recently deglaciated valleys, while the broad upland valley level itself has suffered much less from the ice action. This is to be expected from a knowledge of the mechanics of streams.

English Lakes.—In this region one finds a wonderful development of lake basins, facetted spurs, hanging valleys, ice swept cols, and cirques. Moreover, the situation of the rock basins, hanging valleys and other forms is such as to suggest the agency of a stream in their formation. Consider for example, the decided removal of spurs at the heads of such lakes as Derwentwater, the formation of young cliffs

there and at Wastwater—cliffs produced by such peculiar agencies that, upon exposure to atmospheric conditions, they almost bury themselves with screes in establishing the "angle of repose" under present conditions—and at valley constrictions; consider also the weaker action in forming the spur facets to be seen from the railway just below Keswick, and the absence of such forms still lower down in the valley "broads."

The writer understands that Professor Marr is about to deal with this area in detail in the near future, hence the very brief description here of both this and the associated Pennine district.

Scotland (Blair Athol).—Owing to the kindness of Professor J. W. Gregory of Glasgow, the writer was enabled to take part in one of his University field excursions to the centre of the Highlands at Blair Athol last winter.

General Topography.—The mountain peaks and plateaus in the vicinity of Blair Athol represent the residuals of one or two old surfaces of uncertain age, but evidently no older in appearance than the dismantled Cretaceous or even Tertiary land surfaces of the Eastern United States. In this uplifted surface (or surfaces) a broad upland valley system[1] has been formed by ordinary streams. After elevation, this surface was dismantled in turn by the development in it of mature valley systems. Still later movements have resulted in river revival accompanied by the excavation of deep gorges.

Glacial Phenomena.—Along the sides of a deep valley such as the Glen Tilt for example, hanging valleys are a common feature. Both the main and side valleys are long and straight sided. Cirque forms also are present, and a relatively strong facetting or planing action has apparently occurred in the valley constrictions.

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[1] By many physiographers this Upland Valley surface would be called an immature Peneplain.

A characteristic of the scenery is the intimate association of these deep and strongly glaciated canons with surrounding mountainous country which has not been modified to any great extent by glaciation. An examination of the country reveals the fact that an ice sheet moved over the district and accomplished but relatively slight corrasion of the upland surfaces, while during a later and minor development of valley glaciers the canons appear to have suffered great modification of their profiles.

Assuming that glaciers are capable of great rock corrasion and that the cirques, hanging valleys and long spurless valley walls in the Blair Athol District are due to glacial action, it remains to be seen how an ice cap could apparently do such minor work only and yet a series of mere valley glaciers could accomplish such great work as is here evidenced.

From a consideration of the mechanics of streams it is evident that a stream may pass over an area of well matured or senile topography, (however small or great) without the production of any very pronounced corrasion, at the same time that a younger channel which has been already incised in the older surface may suffer so much from the action of corrasion as to call for comment on the part of even casual observers.

For the stream, all other things being equal, becomes more mobile under increased pressure; the most definite and continuous get-a-way for the stream occurs along the thalweg of the incising gorge rather than along the associated upland surface, hence there is additional reason for increased mobility of that part of the stream which flows along the young channel. This is the analogy of the varying energy between the backwater and the main channel water of an ordinary stream in flood. As in the case of the ordinary stream so in the case of all, the greatest

velocity is not basal but at some varying height above the base and along the main channel. Nevertheless such maximum velocity of a stream does not concern us when the question of the location of maximum stream corrasion only is under consideration. For such stream portion does not come into contact with the channel base or sides. The question which does concern us however when considering the relative corrasive power of various portions of a stream is—"where does the maximum velocity of the stream portion which happens to be in actual contact with the channel structures occur"? The answer to this is—the basal portion of the channel. (See Fig. 2, Part I and descriptive text). The sides and base of the young valley incised into the upland surface will therefore suffer heavy corrasion while the associated upland will experience a relatively weak action.

Upon the shrinkage of the ice cap the valley glaciers will first readjust their channel grades and at a later stage will carry on the work of excavation. Or again the flood stream will seize upon any occasion for local increase of velocity in the matured surface it may be traversing, and then under favourable conditions it will excavate at this spot a basin which will recede with a "step" or cirque head thus forming a youthful valley. Valleys thus may be formed by an ice cap in an upland and channels may be cut back-on declivities. This is the analogy with the action of an ordinary stream which has cut a channel into the bye-wash of a dam.

The Blair Athol occurrences admit of explanation in this manner. An ice cap swarmed over the upland valley level and gave rise to some corrasion there, but along the younger stream valleys it acted much more fiercely. At certain points it excavated "steps" and "treads" along definite lines which under the continuous ice scour receded to form

glacial valleys, and these in turn discharged into the more youthful channels draining the upland surface. During the waning of the ice sheet and the later phase of valley glaciation the channel grades were readjusted and the huge "steps" and "treads" of the earlier glaciation were cut down to make the present long straight-sided hanging and main valleys of the Tilt System.[1]

Post-glacial stream action has formed narrow trenches from 20 to 100 feet deep in these old ice modified surfaces.

7. Kosciusko (New South Wales).—An examination of the plateau of Mount Kosciusko throws much light on the subject of glacial corrasion, because in this locality typical cirques, hanging valleys, facetted spurs and rock basins exist in the closest association with plateaus and profound canons which have been developed by ordinary stream action. Nowhere in the writer's experience is the close association of two such types of topographic profiles so impressive as on this plateau remnant. Even the mingling of glaciated and non-glaciated topographies as seen along the West Coast of New Zealand, and along the Merced River below the famous Yosemite Valley in California, is not nearly so instructive. A peneplain has here been broken; part of it has been hoisted above the snow line of the recent Glacial Period, while the fault scarps, the deep incising gorges, and the portions of the peneplain outside of the Kosciusko areas remained below this snow line; the Kosciusko plateau developed a crop of rock basins, hanging valleys, facetted spurs and cirques, while the lower extra-Kosciusko plateaus exhibit none of these features. The suggestion that here two stream types worked side by side is therefore almost undeniable.

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[1] For a more detailed account of the Highland profiles and their origin see Tarr (b). This is one of the clearest statements yet made as to the peculiarities of glacial topography.

It will be advisable to devote an introductory paragraph or two to the general physiographic features of Kosciusko, so as to throw as much light as possible on the subject of ice corrasion.

The strong glaciation of the Kosciusko Plateau in recent times has been definitely proved by Professor David, Mr. E. F. Pittman, and Mr. R. Helms. As a result of their work[1] two glacial periods at least are known for the plateau, an earlier one during which the locality was covered by an ice cap and a later one during which the glaciers were of the valley type.

General Physiography.—The Kosciusko plateau is an isolated block of the great peneplain of eastern Australia. In the neighbourhood of the Great Divide of the eastern continent, the general height of this now raised peneplain is about 3,000 feet, but in north-eastern Victoria and at Kosciusko (in south-eastern New South Wales) it has been strongly flexed and carried to heights varying from 5,000 to 7,300 feet above sea-level. At Kosciusko itself the flexing has been most pronounced and relief found by faulting. The great fault[2] which separated Kosciusko from the Monaro peneplain which latter is about 3,000 feet less in altitude, was not accomplished by one, but by several steps. The directions of the Snowy and its strong tributary the Thredbo River, were altered by the faulting, and near the junction of the two rivers a stream commenced to work its way back along the line of the fault, and thus developed a profound V-shaped gorge, about 30 miles in length, partly along the fault line and partly beyond it. In working along the line of weakness it captured the Thredbo, and so left the broad matured valley of that strong tributary practi-

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[1] David, T. W. E., Pittman, E. F. and Helms, R , see literature.

[2] David, T. W. E., pp. 659, 660

cally streamless. The youthful gorge in which the captured Thredbo now flows is about 3,000 feet deep.

In passing it may be mentioned that the peneplain itself had been dissected to the old age stage before it had been raised, and furthermore that the upland valley system had been in turn trenched by broad mature and shallow "valley in valley" structures.

As the Thredbo cut its way back through the faulted mountain block, it marched clean across the directions of the streams draining the well matured valleys of the plateau. Thus to one standing on an old flat-floored valley draining the faulted block and looking upstream, the floor apparently ends suddenly in space. On walking up this flat floor one suddenly comes to a sudden break in the country, and looks down a uniform and precipitous slope exceeding 3,000 feet in depth to the present Thredbo gorge. To the front of the observer the whole country apparently has been dropped to a much lower level. Looking along the gorge from a high vantage point on its edge, the ravine appears to run as a fairly straight line which truncates other mature valley floors and walls of the faulted block in its passage. Scarcely any drainage goes from these old valleys into the Thredbo because the fault block slopes away from the latter valley and the great gorge cuts across the old valley floors clean as a knife to the limit of vision.

The Murray gorges are much deeper than those of the Thredbo, and have developed valleys possibly 4,000 feet in depth on the western side of the block. The old well-matured western valleys of the peneplain have by this action been hung up for thousands of feet above the present Murray waters. These, possibly, are some of the finest examples of hanging valleys known to science which have been developed by the methods of ordinary stream revival.

The faulted blocks were tilted towards the upper Snowy River to the north and west of Jindabyne, and that stream shows the influence of such action. Near its head in the mountain summit it exhibits the repeated and characteristic "valley in valley" structure common to the modified peneplain surface. Thence it starts on its torrent track as the fault-block proper is traversed.

Here then we have the singular conditions[1] which obtained in the Kosciusko area during the recent ice periods. In a word an area of a peneplain had been lifted to such a height that the conditions became favourable to the development upon it of glaciers during the recent Ice Age. By faulting and stream action this area became an isolated plateau less than 100,000 acres in extent. After the isolation of Kosciusko by faulting and stream action an ice cap formed on the plateau. (David, T. W. E., see literature). As the glaciers crept over and along the old wide and shallow upland valleys of the fault block, they finally reached the precipitous faces which the block presented to the gorges of the Thredbo and the Murray. At heights less than the general plateau level, however, the conditions were unfavourable for the development of glaciers. On the southern side therefore the ice simply fell in great masses down the unbroken escarpment overlooking the Thredbo River. On the western and northern aspects the Murray receives the drainage of its extremely short hanging valleys, and because the side streams here had excavated narrow although precipitous channel grades to the main stream, the ice cap in this quadrant sent out thin tongues towards the Murray base. These however were

[1] Certain fault blocks in California visited by the writer in company with Dr. G. K. Gilbert and W. D. Johnson show an association of glaciated and non-glaciated topography similar to that of Kosciusko, but their appearance is not so impressive as that of Kosciusko, owing to the great amount of unreduced plateau in the latter locality.

insignificant in size and were rapidly dissipated. The Snowy Valley however presented a gentle fall to the ice cap and was occupied by a long valley glacier.[1] In this now deglaciated Snowy Valley are abundant evidences of the facetting of spurs.

Now the characteristic forms which exist on the deglaciated plateau of Kosciusko to-day are in striking contrast to those to be found on the non-glaciated plateau remnants to the immediate south, west and east, and which were at one time part of the Kosciusko peneplain. They are in striking contrast also to those forms which characterise the V-shaped gorges trenching the upland. On Kosciusko we have Alpine rock basins, hanging valleys, facetted spurs, an abundance of typical cirques and smoothly swept cols. Such features are however characteristically absent from the associated and once continuous but non-glaciated topographies. In this locality it is clear that we have two topographies which were similar even in recent times, but Kosciusko has been lately modified so as to differ from the associated topographies. In addition to this we know that the Kosciusko plateau has been visited by an ice sheet; we know also that its rock basins and facetted spurs occur in just such places as we would expect from a consideration of the principles stated in Part I of this Series, if we assume that glaciers can corrade rock structures. Moreover, from a comparison with the slightly less elevated but non-glaciated portions of the same peneplain, we know that the Kosciusko Plateau did not possess these cirques and allied forms prior to its glaciation. It seems reasonable to conclude therefore that the cirques, the facetted spurs, and the rock basins of Kosciusko are those which have been formed by ice corrasion.

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[1] David, T. W. E., pp. 663, 664.

Conclusions—A. Inductive Studies.

(1) Cirques, hanging valleys, rock basins, facetted spurs (or spurless walls), smoothed cols, "steps" and "treads" occur in all recently glaciated regions.

(2) In proportion to the intensity of the recent glaciation so are these peculiar land profiles pronounced in number, size, and appearance.

(3) In localities not glaciated recently such peculiar land profiles are absent.

(4) All these forms are matched in miniature along any channel determined by thunderstorm waters.

(5) Along the beds of even large stream channels similar forms occur to those just enumerated.

(6) The forms in all these cases are similarly situated with respect to their enveloping channels.

(7) The forms in each case are adjusted to the size of the various stream volumes (whether ice or of water) known to have been associated with them.

B. Deductive Studies.

(1) All streams in nature are due primarily to pressure as weight.

(2) The path of any stream particle tends to the parabolic form.

(3) All must seek the lines of least resistance; and inasmuch as a vertical force (gravity) determines the flow, the lines of least resistance will be the lines of quickest descent for streams.

(4) All streams therefore tend to follow the thalwegs of each other as opportunity arises.

(5) Increased pressure as weight implies the increased mobility or velocity of a stream.

(6) Increased velocity implies corrasive action rising in a high geometrical ratio.

(7) From the foregoing the profiles of all stream channels formed individually by one stream type only should therefore be similar in general appearance.

(8) The forms developed by the general stream have been worked out by means of these principles (see Part I).

(9) But the forms deduced for the general stream are matched in nature in the case of the ordinary water stream (which has been definitely observed moreover to have formed its own channel profiles).

(10) Therefore any group of such similarly shaped, similarly situated, and similarly associated profiles as those deduced for the general stream can be satisfactorily explained by stream action.

(11) But such groups of forms occur in regions of recent glaciation.

(12) They can be satisfactorily explained therefore by stream action.

(13) Moreover glaciers themselves are streams.

(14) Glaciers in recent times occupied the same general relations (as to size, surface and so on) to cirques, lake-basins, over deepened valleys, and other associated forms which the general stream type has been deduced to occupy with regard to its own channel forms.

(15) With the exception of a glacier no other stream in these glaciated regions is known which had the power to fashion the typical cirque, rock basin and spur "facet."

(16) Glaciers therefore, in all probability, formed the typical cirques, the fiord and Alpine basins, the spurless chasms of Alpine regions, as also the hanging valleys and the "steps" and "treads" in Alpine valleys.

C. Apparent lack of ice corrasion as evidenced by a study of present glaciers.—The channel form is adjusted to the strength of the stream. Upon a reduction of stream volume a readjustment of the channel grade is set up, and the stream appears most inert at the locations of the maximum energy exerted by the larger stream.

This is the case with present day glaciers. The recent ice floods formed cirques, rock basins, and other forms adjusted to their own size and strength while the deglaciated valleys of to-day evidence the very recent retreat of the last ice flood. The channel grade therefore must now be readjusted. This being so, morainic material must fall out along the old cutting curves, and the ice generally must be most inert at spots like fiord and lake basins. This explains the apparent anomaly otherwise of the association of inert and banded glaciers with cirques and rock basins, and the occupation of old ice cutting curves by moraines.

APPENDIX I.—*The Path of a Stream Particle.*

Consider the path of a particle with initial velocity u in a direction at angle θ to the horizontal and acted on by the constant gravitational force mg, where $m =$ mass, and g the intensity of gravity or force per unit mass.

Take axes Ox and Oy, as in Fig. 1, Part I of this Series. The velocity along Ox is unaltered throughout motion as the force is vertical, *i.e.* the velocity along Ox is $u \cos \theta$.

Therefore the position of the particle after any time t when measured parallel to Ox is given by $x = u \cos \theta t$.

Position of particle after any time t when measured parallel to Oy is given by

$$y = u \sin \theta t + \tfrac{1}{2} g t^2$$

The path of the particle is obtained by eliminating t from the two equations

$$x = u \cos \theta t \quad \ldots\ldots\ldots\ldots(1)$$
$$y = u \sin \theta t + \tfrac{1}{2} g t^2 \ldots(2)$$

From (1) $t = \dfrac{x}{u \cos \theta}$

Substitute in (2) $\therefore y = x \tan \theta + \tfrac{1}{2} g \dfrac{x^2}{u^2 \cos^2 \theta}$

This gives the equation of the path of the particle. It is that of a parabola.

If u be large the equation approximates to $y = x \tan \theta$, *i.e.*, the path will be near to the straight line $y = x \tan \theta$. or Om in the figure.

If u be small the path approximates to

$$y = x \tan \theta + x^2 \infty$$
$$i.e., x = o$$

i.e., to the straight line Oy.

(After E. M. Wellisch, Emmanuel College, Cambridge.)

Applications.—This tendency of a stream particle to move in a parabolic path may be employed to ascertain the nature of the valley head which is determined by sapping or stream action, or by both actions combined.

The tendency of earth particles forming the walls of a vertical cut in the earth's crust is to fall down under the action of weathering until the "slope of repose" is formed. This is a profile convex to the sky as opposed to the profile of corrasion which should be concave to the sky. Both the profile of corrasion and that of repose tend to the parabolic form. The reason of the respective convexity and concavity with respect to the sky of the profiles of corrasion and of aggradation is obvious. Although both tend to the parabolic form, nevertheless the one is a building, the other a cutting, curve.

The plan of a recessional form all of whose lines of quickest descent tend to become parabolas, is influenced more or less by such a curve itself. In proportion to the strength of the flow which causes the headward recession of the stream, so will the simplicity of the profiles of corrasion be destroyed. In homogeneous structures the plan of the curve of recession will be sharper as the stream action is more decided in strength, but the profiles of corrasion will be flatter.

APPENDIX II.—*Valley head in heterogeneous structures.*

Consider the case of a stream channel excavated in a rock mass which is horizontally disposed and which overlies a relatively weak rock series. If the heavy upper structures be homogeneous among themselves the slope of the channel head will be similar to the forms described in Part I. But so soon as the weak underlying series is exposed, more pronounced sapping of the stronger upper rocks is set up. The amphitheatre form is produced in the incoherent structures, which, under the action of weathering, eddying and other agencies, causes an undermining of the heavy overlying mass. The latter will retreat in cliff form, which in plan will be similar to that of the cirque formed in the lower homogeneous structures.

As an illustration of the tendency of a vertical force to produce these amphitheatres in rock structures whenever a chance offers of a get-a-way for the debris, it may help us here to inquire into the origin of the amphitheatres of the "Red-Wall" limestone as shown in the Grand Canon Section of the Colorado at El Tovar. [See also Davis (d) pp. 178 – 181]. The case in point is chosen because known to geologists the world over.

Here a mass of limestone several hundreds of feet in thickness is divided into two systems, an upper one consisting of relatively thick compact limestone layers not

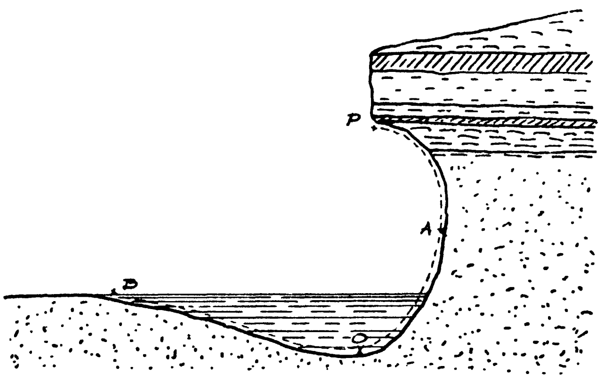
prominently split up by vertical joints, and a lower one consisting of a great number of thin layers of limestone fairly well provided with vertical joints; that is, the upper portion of the Red Wall limestone at this spot appears to be a stronger structure than the lower portion. Under these comes a relatively weak series of shales and sandstones of greenish tint.

Heavy rain storms in very recent times have produced large alluvial fans under the limestone cliffs. Along the Bright Angel Trail, however, an exceptionally heavy storm of more recent date has carried the fans away almost in their entirety. In this process it has exposed a basin of corrasion in the incoherent lower green shales and sandstones. By the formation of this basin a slope of repose has been induced in the weak series. Such sapping action has produced amphitheatres with varying angle of slope. Now this tendency to form amphitheatres in the retreating shales is carried on by gravitative processes unaided by streams to a certain point; the sapping process reaches the limestone and there by reason of its strong vertical joints and abundant stratification planes, it carries the "gravitative curve" into their mass but with steeper angle than that possessed by the curve in the lower and weaker sandstones.

Upon reaching the stronger layers above, the propagation upwards of the sapping movement is progressively weakened and the higher portions actually overhang while the upper curve rapidly flattens (Fig. 12). In this way the reversed "gravitative curve" is produced. Above this reversed curve the Red Wall limestone has the appearance of a cliff and in plan it "curves sympathetically" with the contours of the general amphitheatre of recession. This is the expression of forces which act vertically on material forming the walls of a deep cut, when such cut is either closed

or open at one end. The slower the headward retreat of the cut the greater is the tendency of the plan of the amphitheatre to be a blunt curve. [See also Davis (d) p. 178 – 181] Its vertical profiles tend to become parabolas. The study of this "gravitative" form is especially helpful in the study of the cirque.

Fig. 12.



A O = Gravitative curve or slope induced in material falling freely towards a central gash.

O B = Reversed gravitative curve caused by rapidly dissipating energy of stream.

A P – Reversed gravitative curve caused by gravitative curve passing upward from weaker to stronger structures.

Appendix III.—*Stream Energy.*

In Part I of this series the corrasive strength of streams has been shown to be at least proportional to the square of the stream velocity. The following note suggests that stream corrasion varies as the third power of the velocity. [For the accompanying proof the writer is indebted to Mr. L. A. Cotton of Sydney University.]

Let m be the mass of a substance which is forced to flow past a point A in unit time under the action of gravity.

Let v be its velocity.

Then $\frac{1}{2} m v^2$ = the energy of this mass m.

Hence if a perfect barrier were suddenly presented at A to the stream motion the energy destroyed per unit time would be $\frac{1}{2} m v^2$.

But the mass is proportional to the volume of the stream passing in unit time, and this is equal to $s \times v$, where s is the cross section of the stream at A.

Therefore the total energy destroyed in unit time

$$= \tfrac{1}{2} m v^2$$
$$= \tfrac{1}{2} s v \times v^2 = \tfrac{1}{2} s v^3$$

If now we suppose a flood to occur so that the cross section of the stream at A becomes $= k \times s$, and farther suppose the velocity to be raised to $l \times v$.

Then the energy destroyed per second in this case

$$= \tfrac{1}{2} k s \times (l v)^3$$
$$= \tfrac{1}{2} k l^3 s v^3$$

Hence the ratio of the total energy of the flood stream to that of the normal stream

$$= \frac{\frac{1}{2} k l^3 s v^3}{\frac{1}{2} s v^3} = k l^3$$

This ratio $k l^3$ should be therefore a minimum for the corrasive strength of the stream. In the flood stream therefore the vertical, lateral, and longitudinal measures of strength all rapidly increase with the velocity.

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NOTES ON THE PHYSIOGRAPHY OF THE SOUTHERN TABLELAND OF NEW SOUTH WALES.

By C. A. SÜSSMILCH, F.G.S.

[With Plates IX, X, XI, XII, XIII, XIV.]

[*Read before the Royal Society of N. S. Wales, November 3, 1909.*]

TABLE OF CONTENTS.

A. Introduction.—The following notes are the results of observations made during several vacation trips across the southern tableland of New South Wales. The area dealt with is so extensive and most of it so inaccessible, that a very

large amount of time and travel would be necessary, before a complete description of its physiography could be possible. These notes, therefore, are to some extent suggestive, and are put forward with the object of directing the attention of physiographers to this interesting region. They are, however, so far as circumstances permitted, the result of careful observation in the field, and the conclusions drawn, although they may need modification as more complete data are available, should serve as a basis for further physiographical work in this area.

I have to acknowledge much kindly advice and assistance received from Mr. E. C. Andrews, I had the pleasure of his company on two of my visits to this district, and it was at his suggestion that the work was undertaken. I have also to thank Prof. T. W. E. David for my first visit to the Southern Tableland in company with Mr. Andrews and himself; it was this visit and the discussions which took place during it, that fixed my interest on this fascinating branch of geology.

B. Previous Observers.—In 1860 the Rev. W. B. Clarke in his Southern Goldfield of N. S. Wales, referring to that portion of the valley of the Murrumbidgee which lies between Michelago and Cooma, suggested that it was a synclinal valley. He thus was of the opinion that it was a "structural" valley and not an erosion valley.

In 1901 E. C. Andrews[1] in his description of the Geology of the Kiandra District gave a brief description of the physiography of that area.

In 1901, Messrs. David, Helms and Pittman[2] described evidences of glaciation on the Kosciusko tableland. This paper gives a complete list of previous observers for this region, which therefore is omitted here.

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[1] Mineral Resources of N. S. Wales, No. 10, 1901, Department of Mines N. S. Wales, Report on the Kiandra Lead, by E. C. Andrews, B.A.

[2] Proc. Linn. Soc. N.S. Wales, 1901, Vol. xxvi. pp. 26 – 74.

In 1907, J. Griffith Taylor[1] described the Lake George Basin and comes to the conclusion that it occupied an area of subsidence (Senkungsfeld) bounded on the west by a fault plane with a throw of about 400 feet. This he calls the Cullarin Fault.

In 1908, Prof. T. W. E. David[2] gave a further description of the glaciation of the Kosciusko tableland with some notes on the physiography of adjoining areas. These notes will be quoted later.

C. General Description.—The area to be referred to and termed the Southern Tableland, extends from the southern border of New South Wales to that part of the southern railway line joining Goulburn and Cootamundra. A line south from the latter town to the Victorian border forms (approximately) the western boundary, while to the east lies the Pacific Ocean. The line taken for the northern boundary may not be a very natural one, but is convenient for the writer's present purpose. The northern and north-western part of this area is drained by the Murrumbidgee River and its tributaries, the southern and south-western portion by the Snowy and Murray Rivers, while the Shoalhaven and various coastal rivers drain the eastern portion. In it, therefore, lie the sources of some of our largest rivers. The altitude of different portions of this area varies considerably, so much so, that it is really a group of distinct tablelands, which are separated from one another in most cases by abrupt differences in elevation. The following is a list of these separate areas, with the names suggested for them together with their approximate elevation above sea-level :—

	Altitude.
The Yass-Canberra Tableland ...	1,800 – 2,000 feet
The Kiandra Tableland	4,800 ,,
The Tinderry Tableland	4,000 ,,

[1] *Loc cit.*, Vol. XXXII, part 2, p. 335. [2] *Loc. cit.*, Vol. XXXIII. p. 657.

		Altitude.
The Berridale Tableland ...	...	3,100 – 3,200 feet
The Adaminaby Tableland	...	4,000 ,,
The Kosciusko Tableland ...	...	6,000 ,,
The Yarrangobilly Tableland	...	4,000 ,,
The Colinton Senkungsfeld	...	2,400 – 2,600 ,,
The Jindabyne Senkungsfeld	...	3,000? ,,

The two last being relatively narrow and bounded by much higher areas, cannot of course be called tablelands, and the reasons for calling them Senkungsfelds will be given later. As already stated, where these tablelands adjoin, the change in altitude is in nearly every case abrupt, markedly so in some cases. The details of the topography on all of them is strikingly similar, except where it has been modified by subsequent ice-action, as on the Kosciusko tableland.

The coastal portion of this area east of the main divide, has not been visited and will not, therefore, be described here. It will probably be found that here, as elsewhere in New South Wales, the tableland has a general slope to the coast and has been considerably dissected since the last uplift.

D. Description of the Yass-Canberra Tableland.—The topography of this area is so essentially similar to that of the other parts of the southern tableland that it may be taken as the general type. The surface 1,800 – 2,000 feet in altitude consists of extensive gently undulating plains (see *Plate 11*, fig. 1) traversed in all directions by broad, shallow mature valleys 100 to 200 feet in depth. Rising above these plains occur isolated hills, such as Bowning Hill (*Plate 9*) and Mount Ainslie, also long narrow ridges such as the Razorback between Goulburn and Gunning. The underlying rocks consist of highly inclined Silurian and Devonian sedimentaries extensively intruded by granites

and quartz porphyries. The surface of this tableland is a peneplain cut out of these rocks, and subsequently elevated to its present altitude. It is proposed to call this erosion level the Monaro peneplain. The isolated hills and ridges which rise above this peneplain include the following, these being the only ones whose altitudes are available to the writer :—

	Height above sea-level.		Height above peneplain level.
Barren Jack Mountain ...	3,162 feet	...	1,162 feet
Narrungullen (?)	3,411 ,,	...	1,411 ,,
Bowning Hill	2,608 ,,	...	608 ,,
Black Mountain	2,756 ,,	...	756 ,,
Mount Ainslie	2,762 ,,	...	762 ,,
Spring Trig. Station ...	2,904 ,,	...	904 ,,
Caroll Trig. Station ...	2,811 ,,	...	811 ,,
Parson Trig. Station ...	2,659 ,,	...	659 ,,
Goodradigbee Trig. Station	2,632 ,,	...	632 ,,

It is probable, as will be discussed later, that these are remnants of two distinct erosion levels, one from 700 to 800 higher, and the other about 1,300 feet higher than the Monaro peneplain. For purposes of convenience the former will be referred to as the Mount Ainslie peneplain, and the latter as the Barren Jack peneplain, it being understood however that the existence of these as two distinct erosion levels needs confirmation.

Intrenched in the Yass-Canberra tableland are the valleys of the Murrumbidgee River and its tributaries, cut out during the existing cycle of erosion. Where the course of these streams is through soft rocks, as at Taemas, the valleys have reached the early mature stage of their development (see *Plate 12*, fig. 1), but where they are in hard rock as at Barren Jack, the valleys are typical V-shaped gorges (see *Plate 10*).

The physiographical features of this area may then be summarised as follows: a tableland 2,000 feet high resulting from the elevation of a peneplain, on the surface of which are broad shallow mature valleys and above which rise residuals of one or more older peneplains. Intersecting this tableland are the more or less youthful valleys of the Murrumbidgee River and its tributaries.

The Yass-Canberra Tableland extends eastwards past Goulburn, practically to the coast and swings round northwards to Moss Vale and Mittagong. Throughout this extensive area it has a general altitude of about 2,000 feet. Followed westward it gradually decreases in altitude until it merges into the western plains. To the north lies the central tableland of New South Wales, about 3,000 feet high; to the south lies the Kiandra-Murrumbidgee tableland 4,000 to 4,800 feet in altitude, from which it is probably separated by a series of faults as indicated in the section from Kiandra to Bowning. This latter is purely a suggestion however, based on the appearance of the intervening country as seen from the Yass tableland, as the writer has had no opportunity of traversing this part of the southern tableland. On the eastern extension of the Yass-Canberra tableland lies the Lake George Senkungsfeld described by T. Griffith Taylor.

E. The Fault Blocks.—The occurrence of two adjoining areas whose topography has arrived at a similar stage of development, but which stand at different altitudes can be explained either as the result of warping or of faulting. If the change in altitude, in passing from one area to the other is abrupt, it is most probably due to faulting. It has already been pointed out that the change in altitude between the different sections of the southern tableland is in nearly every case decidedly abrupt, and this, taken in conjunction with the fact that the topography on the

surfaces of all of these sections has arrived at the same stage of development, indicates that they are separated from one another by faults, and are therefore fault blocks or horsts.

I. *The Yarrangobilly Fault Block.*—The Monaro peneplain has here an elevation of 4,000 to 4,200 feet. Residuals of the older peneplains are not very numerous. The Tumut River which drains this area is entrenched in a V-shaped gorge about 3,000 feet in depth. The junction of this fault block with the low lying country to the west has not been examined, but viewed from a distance, the edge of it appears to be a fault escarpment. From the higher Kiandra fault block to the east it is separated by two faults hading to the west and with a total throw of about 700 feet. The road from Yarrangobilly to Kiandra passes over these faults, a very steep grade on the road marking the position of the fault scarp. The narrow strip of country between these two faults shows the same topography as the surfaces of the tablelands above and below.

II. *The Kiandra Fault Block.*—On this area the Yass-Canberra peneplain stands at an elevation of about 4,800 feet. Numerous residuals of the older peneplains occur, of which the following are the more important:—

	Actual elevation.	Approximate elevation above the Monaro peneplain.
Bimberry Peak ...	... 6,264 feet ...	1,464 feet
Half Moon Peak ...	6,144 ,, ...	1,341 ,,
Tabletop Mountain ...	5,850 ,, ...	1,050 ,,
Boboyan Peak ...	5,781 ,, ...	981 ,,
Bald Hill	5,776 ,, ...	976 ,,
Round Mountain ...	5,755 ,, ...	955 ,,

In addition to these many others ranging up to 5,600 feet in altitude occur. The altitudes given above are those supplied by the State Trigonometrical Survey chart.

This fault block may extend as far east as the Murrumbidgee Fault immediately west of the Cooma Railway line, but as this part of the tableland has not been ascended by the writer, the matter must remain in doubt for the present. Judging by the heights of the trigonometrical stations, however, which occur hereabouts, it must be nearly, if not quite as high as that part in the neighbourhood of Kiandra. Should it be shown later that it stands at a lower level than 4,800 feet, it might then be necessary to consider it as a separate fault block, and as it is nearly encircled by the Murrumbidgee River, the name Murrumbidgee Fault Block would be appropriate. In any case it is perhaps desirable to use the name Murrumbidgee Tableland for this eastern area. The fault marking its eastern boundary hades to the east, has a throw of at least 1,500 feet, and will be called in this note the Murrumbidgee Fault. It continues as far north at least as Tharwa; followed in a southerly direction it passes just west of Cooma, where its throw is only about 400 to 500 feet, and then gradually dies out as the water-shed between the Murrumbidgee and Snowy Rivers is approached.

III. *The Adaminaby Fault Block.*—The road from Kiandra to Cooma, soon after leaving the former town, enters a series of gorges, and drops rapidly by a steep descent to an altitude of about 4,000 feet at Perseverance Flat. These gorges have been cut into what are probably one or more fault escarpments separating the Kiandra and Adaminaby tableland. From here, past Adaminaby, to Rhine Falls the topography is similar to that on the Kiandra tableland, in other words the Monaro peneplain has here an altitude of about 4,000 feet. This fault block is relatively narrow in an east and west direction, but extends for many miles in a southerly direction, with a somewhat decreasing altitude. Where the Cooma-Jinda-

byne road crosses it at Barney's Ridge, it is a veritable "horst," being only a few miles in width, with the Jindabyne Senkungsfeld to the west and the relatively lower Berridale fault block to the east.

The southern portion of the Adaminaby fault block is bounded on the west by the faults referred to by Professor David,[1] which have a throw of about 800 feet, strike north and south and hade to the west. It will be convenient to refer to these as the Jindabyne faults. The eastern boundary is another fault also mentioned by Professor David near Lake Coolamatong; this has also an approximate north and south strike, but hades to the east and has a throw of 700 to 800 feet. Further north at Rhine Falls where the Cooma road drops from the Adaminaby tableland to the Berridale tableland two faults occur, with a combined throw of about 900 feet. These have a similar hade and strike to the Coolamatong fault, and may be called the Rhine Falls Faults.

IV. *The Berridale Fault Block.*—This has an extensive area extending from the Murrumbidgee River to probably as far south as the Victorian border. It is bordered on the west by the Adaminaby fault block, but its southern and south-eastern limits have not been investigated. In the northern part of this area the Monaro peneplain has an altitude of 3,000 to 3,200 feet, but its surface has suffered considerable warping during uplift, as evidenced by the considerable number of small lakes and lagoons scattered over its surface, the existence of which can be best explained as the result of warping. Lake Coolamatong may be quoted as an example. Residuals of the Mount Ainslie peneplain occur, such as Mount Gladstone (3,529 feet, and The Brothers (3,859 feet).

[1] Geological Note on Kosciusko by Prof. T. W. E. David. Proc. Linn. Soc. N.S.W., Vol. xxxii, pp. 657 – 668.

V. *Tinderry Fault Block.*—This is situated some ten miles to the east of Michelago on the Cooma railway line. The writer has only seen it from a distance and is therefore unable to give first-hand observations. Some information can be gathered, however, from the altitudes of the Trigonometrical Stations, which include the following:—

Tinderry Pic	5,307 feet.	Tumanang	4,835 feet.
The Bald Mountain	4,812 ,,	Tumanmang	4,656 ,,
Holland Trig.	4,563 ,,	Anembo	4,642 ,,

As none of the residuals (these higher trigonometrical stations are most probably on residuals) in the other parts of the southern tableland are much over 1,300 feet above the level of the Monaro peneplain, it is probable that where these high points occur this peneplain has an elevation of about 4,000 feet. This would give the surface of the Tinderry fault block an altitude of about 4,000 feet. In any case there can be no doubt that it has a very considerable altitude. Its western edge is marked by a fine fault escarpment, very probably a continuation of the fault described by T. G. Taylor[1] as occurring along the western side of the Lake George Senkungsfeld. This fault will be called here the Tinderry Fault; it hades to the east and has a throw of probably at least 1,500 feet. Followed to the south this fault rapidly dies away. The area of this fault block is apparently limited, extending little beyond the main divide to the east, and no further than Bredbo Creek to the south.

VI. *Kosciusko Fault Block.*—This is the highest of all the fault blocks and is the most elevated region on the Australian continent. Prof. T. W. E. David[2] gives the following summary of his conclusions regarding the physio-

[1] The Lake George Senkungsfeld by T. G. Taylor, B.Sc., B.E. Proc. Linn. Soc. N.S.W. Vol. XXXII, part 2.

[2] Geological Notes on Kosciusko by Prof. T. W. E. David. Proc. Linn. Soc. N.S.W., Vol. XXXIII, p. 666.

graphy of this area :—"A late Tertiary peneplain formed of granite, gneissic rocks and schists was uplifted to a general level of 3,000 feet above the sea. From Cooma towards Kosciusko a further upward warping took place which lead to the peneplain acquiring an inclination towards the north and east; this gave the Snowy River its original N.N.E. trend near its source. As the warping progressed, and the earth's crust towards the S.E. of the Kosciusko plateau was put in tension, shearing followed, resulting in the great fault along the Thredbo Valley. Cross-faults also developed at Pretty Point and along Diggers' Creek, marked now by a strong feature as well as freshwater springs and probably also at Sawpit Creek. Possibly another fault may have formed on the S.E. side of the Snowy Valley producing a long, narrow trough, possibly a lake may have been produced at the bottom of the trough, and the remarkable gravel banks to be seen two miles to the S.E. of the accommodation house on the Thredbo may be of lacustrine origin and antedate the cutting down of the rocky bar below Jindabyne. The fault with its easterly throw at Barney's Ridge, which may have given origin to Lake Coolamatong, may have formed about the same time."

In the writer's opinion the faults referred to as occurring at Pretty Point, Diggers' Creek and Sawpit Creek undoubtedly exist. They hade to the east and have a combined throw of at least 3,000 feet. These fault escarpments form the eastern edge of the Kosciusko fault block, separating it from the Jindabyne Senkungsfeld. Another great fault or series of faults separates the Kosciusko tableland from the lower lying country to the west. The northern and southern limit of this tableland have still to be determined. From a distance the Kosciusko and Kiandra fault blocks seem to be distinctly separated from one another with lower country lying between, but this requires con-

firmation. The Monaro peneplain on the Kosciusko tableland has an elevation of at least 6,000 feet with residuals of the older peneplain rising above it, and include the following :—

	Altitude.		Approximate height above Yass-Canberra peneplain.
Mount Kosciusko	7,328 feet	...	1,328 feet
Mount Townsend	7,260 „	...	1,260 „
Gungartan	6,776 „	...	776 „
Big Bogong	6,755 „	...	775 „
Ram's Head	6,600 „	...	600 „
Mount Clarke	7,000 „	...	1,000 „
The Perisher	6,550 „	...	550 „
Mount Etheridge	7,000 „	...	1,000 „

F. The Senkungsfelder.—These consist of relatively narrow portions of the Yass-Canberra peneplain, which during the elevation initiating the existing cycle of erosion, were elevated less than their immediate neighbours, they thus appear now as depressed segments. It is unlikely that these two areas have suffered any actual subsidence, their relatively lower elevation being the result of their lagging behind during the differential uplift of the whole region. If subsidence of these two areas, however, did follow elevation, it must have done so immediately, *i.e.*, without any considerable interval of time between the uplift and subsequent subsidence. In either case it is convenient to call these relatively depressed segments—Senkungsfelder.

I. *The Jindabyne Senkungsfeld.*—This has a general elevation of just under 3,000 feet, it is bounded on the west by the Kosciusko fault block (6,000 feet high), and on the east by the southern extension of the Adaminaby fault block (3,700 - 4,000 feet high). At Jindabyne it is only a few miles wide and might be mistaken for a valley of erosion,

to the south, however, it spreads out considerably and loses its typical "Senkungsfeld" nature and appears also to increase in altitude. Professor David in the paper already referred to, makes the following observations on it :—"It was pointed out by Mr. Andrews that at the top of the long hill bounding the Snowy Valley on the east, at thirty-two miles from Cooma towards Jindabyne, the small hanging valley, which there descends through a rocky precipitous channel into the broad valley of the Snowy, possibly owes its origin to a strong fault throwing down westwards. Certainly the great width of the Snowy Valley, between two and three miles at this point, is a puzzling feature. Below Jindabyne the valley is narrowed in by rocky rounded foot hills, through which the Snowy River has cut a zig-zag gorge with overlapping spurs. The question suggests itself, is this wide flat valley with its rounded rocky foot hills, due to the glaciation accompanied by a Piedmont glacier supplied by cascades of ice formerly pouring over the edges of the Kosciusko plateau in their passage to the east? Or is this feature due to trough faulting? Is the Snowy valley above Jindabyne on the side of a narrow Senkungsfeld or trough fault?"

The writer is of opinion that no evidence of glaciation exists and believes that trough faulting affords the most satisfactory explanation of the peculiar feature of this region. Mr. E. C. Andrews, has, however, been making a study of this particular area in connection with the development of the Snowy River, and the results of his investigation will be awaited with interest. The writer would suggest that the faults bounding the western side be called the Pretty Point faults, and those on the eastern side be called the Jindabyne faults.

II. *The Colinton Senkungsfeld.*—This lies along the course of the Murrumbidgee River from Cooma to Michel-

ago. To the west it is bounded by the Murrumbidgee tableland, and to the east by the Tinderry tableland, both 4,000 feet or more in altitude. To the north it expands and merges into the Yass-Canberra tableland, while to the south it merges into the Berridale tableland. This section of the southern tableland was tilted during uplift and the Monaro peneplain which has an elevation of about 3,000 feet at the junction with the Berridale tableland is inclined towards the north, so that where it joins the Yass-Canberra tableland the altitude is only about 2,000 feet. As will be shown later, this tilting has had an important influence in modifying the drainage systems. Residuals of the Mount Ainslie peneplain are numerous; in the neighbourhood of Bredbo and Colinton they are so crowded together as to mask the true nature of the Monaro peneplain, which here consists of broad, flat-bottomed mature valleys separated by ridges 600 to 700 feet in altitude. This locality has every appearance of having been a main divide during the previous cycle of erosion.

It is the Murrumbidgee and Tinderry faults which separate this Senkungsfeld from the Murrumbidgee and Berridale fault blocks to the west and the Tindery tableland to the east.

G. The Fault Escarpments.—When an area with an approximately level surface is separated during elevation into two portions by faulting, that portion which has suffered least elevation will naturally form a temporary base level for the streams which flow to it from the higher portion. Such rejuvenated streams starting at the fault escarpment where they will have a steep grade, begin to entrench themselves in their old courses and cut down their valleys to the new base level. If the uplift and faulting are of comparatively recent geological age, the extent to which the streams have cut back into the higher tableland

will be inconsiderable, except in the case of the larger streams. Consequently we may expect to find a narrow zone of youthful topography cut into the fault escarpment and separating a higher and a lower region of mature topography. The streams on the higher tableland will be winding sluggishly in mature valleys; followed downstream they plunge into relatively deep gorges with a steep grade as the fault escarpment is approached, only to leave and again meander in the mature valleys of the lower tableland. All these features are well seen at the junctions of the fault blocks in the southern tableland of New South Wales. The Murrumbidgee fault-scarp between Bredbo and Michelago has been but little modified in this way, but appears as a great wall running approximately north and south with the Murrumbidgee River flowing at its foot. All the important tributaries which this stream receives on its left side such as the Nass, Gudgenby, Cotter, and Goodradigbee flow due north, parallel to the course of the parent stream and do not cut across this fault escarpment. The Murrumbidgee itself cuts across it farther south, near Bunyan, and there it has cut a deep gorge into the Berridale fault block. The Coolamatong and Rhine Falls fault-scarps while not so large and imposing as the one above referred to, are very typical and striking examples. From a distance, of course, they look like mountain ranges, and it is only when one passes over them in ascending to the tableland above, that their true nature becomes apparent. Where the larger streams cut across these fault escarpments and particularly where the difference in elevation between the two tablelands is considerable, deep gorges have been excavated heading back into the higher tableland, such as those of the Snowy and Crackenback Rivers, where they head into the Kosciusko tableland, the Goodradigbee where it heads into the Kiandra-Murrumbidgee tableland, and the Tumut River where it intersects the Yarrangobilly tableland.

H. The Peneplains.—Reference has already been made, when describing the Yass-Canberra tableland, to the probable existence of three distinct peneplains. It is now proposed to discuss the evidence in support of the existence of these throughout the southern tableland generally.

1. *The Monaro Peneplain.*—This constitutes the general surface of all the subdivisions of the southern tableland. It has been cut out of a complex series of lower palæozoic sedimentaries and metamorphic rocks, extensively intruded by acid igneous rocks. The sedimentaries consist mainly of shales, limestones and tuffs, the metamorphic rocks consist of gneiss, mica and talcose schists, phyllites, etc., while the intrusive igneous rocks consist mainly of granite and quartz porphyry. The so-called Monaro plains and the Yass plains are typical examples of this peneplain. In the neighbourhood of the main divides which existed during its formation, it splits up, finger-like, into mature valleys, separated by residuals of the tableland out of which it has been eroded; this feature is well shown in the district to the west of the railway line between Bredbo and Cooma.

2. *The Barren Jack Peneplain.*—Throughout this area occasional more or less isolated peaks occur, which rise to an altitude of upwards of 1,000 feet above the Monaro peneplain. These include the following:—

RESIDUALS OF THE BARREN JACK PLAIN.

Name.	Section of the Southern Tableland on which they occur.	Actual Altitude.	Altitude above Monaro Peneplain.
		Feet.	Feet.
Mount Kosciusko*	Kosciusko Tableland	7,328	1,328
Mount Townsend*	Ditto ...	7,260	1,260
Mount Clarke* ...	Ditto ...	7,000	1,000
Mount Etheridge*	Ditto ...	7,000	1,000
Bimberry Peak ..	Kiandra Tableland ..	6,264	1,464
Half-Moon Peak ...	Ditto ...	6,144	1,344
Table-top Mountain	Ditto ...	5,850	1,050
Tindery Pie* ...	Tinderry Tableland...	5,307	1,307(?)
Lampe	Yarrangobilly „ ...	5,338	1,338
Barren Jack* ...	Yass-Canberra „ ...	3,162	1,162
Narrungullen (?) ...	Ditto ...	3,411	1,411
Rob Roy	Ditto ...	3,585	1,285(!)

Those marked with an asterisk are composed of acid igneous rocks; the rocks present on the others are unknown to the writer. Table-top mountain has a capping of 200 feet or more of basalt and may possibly be a residual of the Mount Ainslie peneplain. These monadnocks obviously must represent residuals of an old erosion level—the oldest in this part of Australia. With one exception, (Bimbery Peak) the highest are from 1,300 to 1,400 feet higher than the younger peneplain on which they stand, and this may therefore be taken as the approximate height of the Barren Jack plain above the Monaro peneplain.

3. *The Mount Ainslie Peneplain* (?)—On the Yass-Canberra tableland, of those residuals whose altitudes are available to the writer, three only are 1,000 feet higher than the Monaro peneplain. The highest of the remainder except Spring Trigonometrical Station, range between 700 and 800 feet; this exception may be a denuded residual of the Barren Jack plain. In the district surrounding Bredbo on the Murrumbidgee Senkungsfeld, residuals are very numerous, most of which reach a maximum altitude of about 700 feet above the Monaro peneplain. On the Berridale and Adaminaby tablelands no residuals are known to the writer exceeding 800 feet in altitude above the Monaro peneplain. On the Yarrangobilly tableland but one is known exceeding a similar altitude, viz., Lampie, included in above list as a residual of the Barren Jack plain. On the Kiandra tableland so many residuals ranging from 400 up to 1,464 feet higher than the Monaro peneplain occur, that no safe inferences can be drawn; many of them, however, range from 700 to 800 feet.

Taking such evidence as is available, it would seem, therefore, a fair assumption that a peneplain 700 to 800 feet higher than the Monaro peneplain and quite distinct from the Barren Jack plain occurs.

Age of the Peneplains.—Beyond the occurrence of Tertiary fossil plants in the alluvium under the basalt flows on the surface of the Monaro peneplain, such as at Dalton near Gunning, no evidence has been obtained which supplies any information as to the geological age of these peneplains. Nor is it at all likely under the circumstances that any satisfactory evidence will be forthcoming until the peneplains in the marine tertiaries of Victoria, if such exist, are studied and correlated with those under discussion. As the river valleys which have been cut into the tablelands since the uplift of the youngest peneplain, are still for the most part mere gorges, it seems improbable that the uplift can have taken place earlier than the Middle Tertiary.

Use of the Term Peneplain.—It would, perhaps, be desirable to define the sense in which the term peneplain is here used, as the usage seems to vary with different writers. When a tableland is uplifted above sea level, a cycle of erosion is initiated, which, if continued sufficiently long without interruption, may result in the entire removal of that tableland, with the production of what is essentially a plain at or near sea-level. As such a surface is hardly likely to ever be perfectly level it has been called a peneplain.

Complete planation, however, seldom occurs during a single cycle of erosion, residuals of the tableland still remaining when the cycle is interrupted by some new earth movement. To what extent may residuals remain and the feature be still called a peneplain? If the cycle of erosion has been long continued, very extensive areas may have suffered complete pene-planation, yet in other parts, particularly in the neighbourhood of the main divides, numerous residuals, the tops of many of which are portions of the original tableland surface, and even considerable flat-topped areas of the original tableland may remain; so that, what

is essentially a plain in one part of such an area, may merge into a series of mature or even youthful valleys in another part of the same area.

The writer is of opinion that in an extensive area such an erosion surface may be called a peneplain, provided that the unreduced portions of the original tableland are relatively very small compared to that which has been removed. With this wider use of the term remnants of two or more peneplains can, of course, occur in one and the same area.

I. The Murrumbidgee River.—To any student of physiography who has followed the course of the Murrumbidgee on the map, that course must appear to be strikingly anomalous. This river has its source on the southern side of Peppercorn Hill, in the parish of that name, in the county of Buccleugh. For about 80 miles it flows in a south and south-easterly direction; a few miles from Cooma it suddenly turns due north and flows in this direction for another 80 miles or more; it then turns westward and maintains that direction more or less until its junction with the Murray River. The main divide of New South Wales runs approximately north and south, and from this divide numerous consequent streams flow west and east. The westerly flowing portion of the Murrumbidgee River is one of these consequent streams, and as such presents no features of special interest. The anomalous course of the Upper Murrumbidgee and particularly the remarkable bend near Cooma, however, demand explanation. The remarkable bending of the main divide where it forms the watershed between the Upper Murrumbidgee and the Snowy, strongly suggests the piracy of part of the catchment area of this latter stream by the former. Special attention was given to the elucidation of this problem, the results of which confirm the above suggestion.

Description of the Valley of the Murrumbidgee River.—From Barren Jack to Canberra the river is entrenched in the Yass-Canberra tableland; its valley varies from a typical V-shaped gorge, where it cuts through resistant rocks, to the early mature type with narrow flood plains, but steep valley walls, where it has been cut out of the softer rocks. At Taemas the bed of the stream is still 1,000 feet above sea level and about 900 feet below the surface of the tableland. Four or five distinct erosion levels (rock benches) occur on the sides of the valley, indicating that the elevation which rejuvenated this stream was probably an intermittent one. Since the beginning of the elevation which produced the tableland, the river has then, along this part of its course cut out a valley 900 feet in depth, and still youthful in character; while it still has to cut its bed downwards to a considerable depth before base level is reached. From Michelago to Bunyan Hill (near Cooma) the valley is shallow and mature, the river flowing practically on the surface of the Monaro peneplain except for a few miles between Colinton and Bredbo, where it flows in a gorge about 500 to 600 feet in depth—a gorge cut through some of the residuals of the Mount Ainslie peneplain. Throughout this part of its course it flows at the foot of the Murrumbidgee fault escarpment and on its western bank receives only one tributary of any importance, the Gap Creek, which lies at the bottom of a deep gorge; but on its eastern bank, numerous tributaries such as Bredbo Creek and the Umaralla River occur. These head back to the main divide and all occupy—for miles away from their junction with the Murrumbidgee River—broad mature valleys, which are heavily aggraded.

It is here that the Murrumbidgee River flows through the Colinton Senkungsfeld a feature which has usually been looked upon as an ordinary river valley. If this were the case, what has been described in these notes as the

Murrumbidgee fault escarpment would be the western wall of the valley, the valley itself would be 1,500 feet deep, several miles in width, and with thoroughly mature topography within its walls. How could this be reconciled with the characters of the valley lower down stream, at Taemas, where, although the rocks out of which it has been cut are soft and thinly-bedded shales and limestones, it has hardly passed its youthful stage of development? Near the Bunyan Hill the Murrumbidgee has crossed the Murrumbidgee fault and heads into the Berridale tableland into which it has cut a deep gorge.

Development of the Upper Murrumbidgee.—That part of the divide separating the Snowy River and Murrumbidgee watersheds, which lies to the south of Cooma, and is called on maps the Main Dividing Range, is very low. Where the road from Cooma to Berridale crosses it, it is really an almost level plain (the Monaro peneplain), and in passing over it one can hardly realize that it is a divide separating two important and extensive drainage areas. Standing on top of the Bunyan Hill near Cooma and looking north along the valley of the Murrumbidgee in the direction of its present flow, one sees what appears to be a continuous chain of hills standing athwart its course and apparently blocking any possible drainage in that direction. Looking south on the other hand, one sees the Monaro plains stretching west and south, and bounded in the far distance by a low range of hills—the main divide. In this range and due south from the observer, there is a gap many miles in width. No stream flows through this gap—it is a "wind gap." Anyone unfamiliar with the direction of flow of the streams, would from this point of observation, certainly come to the conclusion that all the drainage was flowing to the south and through the above mentioned wind gap. Yet this same gap forms part of the existing divide and through it extends a great plain.

The group of hills referred to as apparently blocking the course of the river to the north, are situated between Bredbo and Colinton. They are, as already pointed out, residuals of the Mount Ainslie peneplain and form a sort of bridge, stretching from the Tinderry to the Murrumbidgee tablelands, and dividing the Colinton Senkungsfeld into a northern and southern portion. As this locality is approached, either from the north or from the south, the Monaro peneplain narrows more and more and finally splits up finger-like into a series of mature valleys. These features suggest that this was at one-time a divide between two river systems. Above and below this ridge the Murrumbidgee winds sluggishly in a mature valley, but in passing through it, as already described, it is confined in a narrow gorge. The Monaro peneplain throughout the Colinton Senkungsfeld has a tilt from south to north—there being a difference of about 1,000 feet between the southern and northern ends. It has also a small tilt from east to west. Taking all these facts into consideration it seems probable that at one time, all that part of the existing drainage area of the Murrumbidgee River, south from this suggested old divide, formed part of the drainage area of the Snowy River, and that the drainage from it flowed through the wind gap which exists in the main divide, where it is crossed by the Cooma-Berridale road. This capture would have been made possible by the warping, faulting, and tilting of the Monaro peneplain during its uplift.

J. Summary.—The Southern Tableland of New South Wales consists of a number of fault-blocks produced by the differential uplift of an extensive peneplain, this uplift varying in amount from 2,000 to 6,000 feet. The strains produced by this unequal movement developed a number of faults, the more important of which have an approximately meridional strike. During the uplift several portions of this

area lagged behind and now appear as relatively depressed segments or "Senkungsfelder." The development of these Senkungsfelder has brought about a considerable modification of the pre-existing drainage systems, resulting in extensive river-capture in the case of the Murrumbidgee and Snowy Rivers and the formation of an inland drainage area in the case of the Lake George Senkungsfeld. Above the surface of the youngest peneplain (the Monaro peneplain) rise numerous residuals of two older peneplains. The river valleys cut out during the existing cycle of erosion, have not yet passed the early mature stage of development and in most cases are still in the youthful stage of development. The succession of events which has produced the topography of this region may be briefly summarised (in chronological order) as follows :—

1. A cycle of erosion resulting in the formation of a peneplain approximately at sea level—The Barren Jack Peneplain.

2. An uplift of about 500 – 600 feet converting the plain into a plateau and initiating a new cycle of erosion.

3. The second cycle of erosion with the production of a second peneplain—The Mount Ainslie Peneplain.

4. An uplift of 700 – 800 feet initiating a third cycle of erosion, residuals of the older peneplain still surviving.

5. The third cycle of erosion with the production of a third peneplain—The Monaro Peneplain. This cycle of erosion was less complete than either of its predecessors, many residuals of the older peneplains surviving.

6. A small uplift of about 200 feet followed by the formation of broad mature valleys.

7. Renewed uplift, ranging in amount from 1,800 – 6,000 feet accompanied by extensive faulting, and resulting in the development of a number of fault blocks and Senkungs-

felder, as well as important modification of the pre-existing drainage systems.

8. The existing cycle of erosion which is still in its youthful stage.

NOTE ON THE OCCURRENCE OF MANGANESE IN SOIL AND ITS EFFECT ON GRASS.

By F. B. GUTHRIE, F.I.C., F.C.S., and L. COHEN.

[*Read before the Royal Society of N. S. Wales, November 3, 1909.*]

A sample of soil was received during last month from the Secretary of the Dubbo Bowling Club representative of a number of small patches occurring throughout the green on which the grass had died down during last winter. It is stated that the green was laid down five years ago, and for the first three years was covered with a splendid coat of healthy couch, but last winter and this winter it died in 40 or 50 small patches, ranging from a few inches to two feet in diameter. As the green receives the same treatment throughout, and as both the soil and the climate of the district are admirably adapted to the growth of couch, the problem presented was an interesting one, especially as there was an absence of the sour condition and shallowness of surface-soil frequently associated with such infertile patches. A sample typical of the soil over the remainder of the green and taken from places within three feet of the dead patches was also obtained. A preliminary examination showed that both the soils were very similar in chemical composition, but the fact was noted by one of us, Mr. L. Cohen, that manganese was present in the soil on

which the grass died down and was absent in the other. The following is the result of the analyses of these soils :—

Examination of soil from a dead patch on Dubbo Bowling Green, forwarded together with portion of the healthy soil by E. R. Hawke, Secretary.

	Soil from normal portion	Soil from part where grass dies off.
Reaction	neutral	neutral
Capillary power	9·3 ins.; excellent	6·6 ins.; gocd
Moisture	1·76 %	2·09 %
Volatile and organic matter	5·79 ,,	5·10 ,,
Nitrogen	·063 ,,	·105 ,,
Total water-soluble salts	·039 ,,	·045 ,,
Lime (CaO) soluble in hot HCl ...	·324 ,,	·329 ,,
,, ,, in 1% citric acid... ...	·249 ,,	·220 ,,
Potash (K_2O) soluble in hot HCl ...	·038 ,,	·037 ,,
,, ,, in 1% citric acid... ...	·010 ,,	·011 ,,
Phosphoric acid (P_2O_5) sol. in hot HCl	·122 ,,	·105 ,,
,, ,, in 1% citric acid... ...	·030 ,,	·017 ,,
Oxide of Manganese (Mn_2O_3) total...	·000 ,,	·254 ,,
,, ,, ,, soluble in hot HCl...	·000 ,,	·022 ,,
,, ,, ,, soluble in 1% citric	·000 ,,	·033 ,,

The total manganese was determined by fusion of 2 grms. of the soil with sodium carbonate, the portion soluble in hydrochloric acid was determined in 10 grms of the soil boiled for 20 minutes with hydrochloric acid of 1·1 sp. gr. In the determination of the citric acid soluble manganese, 100 grms. of the soil were shaken with 1 litre of one per cent. citric acid for 20 hours in a mechanical shaker at 50 revolutions per minute.

The only difference shown by the analysis of these two soils is the presence of manganese in the patches on which it is reported that the grass dies down in the winter. It is possible that manganese is present as traces in the other soils, but not in sufficient quantities to give an indication by the methods adopted.

A great number of experiments have been made of recent years, both in pots and in the field, to test the effect of such substances as salts of manganese, zinc, etc., on the growth of plants, particularly by O. Loew and his co-workers at Tokio, and others. A resumé of the work done and references to the original papers will be found in the Annual Reports of the Chemical Society, Vols. I – V. An excellent resumé is also given by G. Pollacci.[1]

On the whole, although the results so far obtained cannot be regarded as entirely conclusive, it appears that manganese compounds in the soil in small quantities exert a stimulating effect on the growth of many crops, but whether that effect is due to the direct action of manganese as plant-food or to a secondary action upon other constituents in the soil is not yet satisfactorily determined. Some chemists state that the presence of manganese is necessary to the growth of the plant, and that it is present in minute quantities in all soils. In the particular case of meadow-grass, G. Salomone[2] found that the pasture was greatly improved by the addition of small quantities of sulphate of manganese, 1 grm. of the metal per square metre (about 27 lbs. of sulphate of manganese per acre) produced a more vigorous growth and of a darker green, the yield of hay calculated to the hectare being 760 kilos greater in the case of the plot which had received the manganese than in the other. The effect on other crops of small quantities of manganese will be found by consulting the references already referred to.

Mr. Cuthbert Potts of the Hawkesbury Agricultural College has also been conducting experiments in this direction, both in the field and in pots. Mr. Potts has experimented with wheat for hay in the field by manuring with

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[1] L'Industria Chimica, Anno 9, No. 5, p. 65, March 10th, 1909.

[2] Le Staz. Sper. Agr. Ital., Vol. XL, p. 108.

20 lbs. sulphate of manganese per acre, applied after the seeds had germinated, and although the season was not a favourable one, and the figures are not conclusive, and in some cases the treated plots did not yield any better than the untreated, he finds that on the average the yield from the untreated plots is somewhat better. In the pot-experiments also, Mr. Potts reports a slight average increase with wheat, tares, and oats on treating the soil with ·001, ·002, and ·005% manganese sulphate. Oats are stated to show the greatest increase.

In larger quantities manganese compounds have been found to act as plant-poisons. G. Salomone[1] finds as the result of experiments in the field, that 50 kilogrammes of manganese sulphate per hectare (about 44 lbs per acre) produce the most favourable results in the case of wheat. Above this quantity the development of the plant is retarded and the proportion of grain and straw diminished. With 80 to 85 kilos per hectare the plants died before flowering, and with 90 kilos per hectare the plants only attained a height of a foot and then suddenly wilted. He finds also that the toxicity of the different salts of manganese increases in those in which it acts as an electronegative element, being greatest in the manganates and permanganates.

A series of interesting experiments has been published by W. P. Kelley[2] of the Hawaii Experiment Station, into the effect of manganese upon the growth of pineapples. He finds that certain areas of the soil in Hawaii on which the plants do not develop, turning yellow in colour and producing inferior fruit, always contain excessive quantities

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[1] Le Staz. Sper. Agric. Ital., Vol. XXXVIII, p. 1015, and Vol. XL, p. 97. In the first paper will be found a good bibliography of previous work on this subject up to 1905.

[2] Journal of Industrial and Engineering Chemistry, Vol. I, No. 8, p. 533 (August 1909).

of manganese compounds. Analyses of these soils show that those on which the pines become yellow contain on the average as much as 5·61% of manganese (calculated as Mn_3O_4) in the surface-soils as against 0·37% in the soils producing the healthy pines. In this case it is to be noted that both soils are highly ferruginous, containing over 20% ferric oxide, the good soil being of a red colour, while the infertile soils are black. He has shown a further interesting point which bears upon the question immediately before us, namely, that on soils containing an intermediate proportion of manganese, (1·36% Mn_3O_4), the pines become distinctly yellow during the winter months, but sometimes recover completely with the return of the warm weather.

Although the quantities of manganese found in the poor soil examined by us is not nearly so great as that in the black Hawaiian soils (containing only ·245% calculated as Mn_3O_4), yet it is possible that the peculiarity noticed in this soil, that the grass dies down in the winter, is due to the same cause, namely, the presence of an amount of manganese not sufficient to kill the plants when growing vigorously, but sufficient to affect them when in a less vigorous state of growth. Aso[1] has also pointed out that the toxic effect of manganese salts on wheat and barley is greatest in the cold weather, the plants recovering themselves completely with the return of warm weather.

That the cause of the failure of the grass in these patches is due to the presence of manganese is only put forward as a suggestion. It is to be noted that the Dubbo soil is not particularly rich in iron, and that the soils do not differ in colour, both being of a brownish colour becoming red on ignition. The peculiar fact that the grass showed no sign of the effect of the poison for the first three years is also

[1] Bulletin, College of Agriculture, Tokio Imperial University 5, No. 2, p. 177.

noted in the case of the Hawaiian soils. W. P. Kelley (*loc. cit.*) reports that the first crop of pines showed but little yellow colour during the first twelve months when grown on the black soils. Later, however, the plants became yellow and refused to grow. The soil itself also appears to become darker in colour with the continued growth of the pines. He concludes from this that there is possibly some change brought about in the soil by the crop itself, resulting in a change in the state of oxidation of the manganese.

Speaking generally concerning what is known of the action of manganese in the soil, it may be regarded as proved that in small quantities it is beneficial to some crops, that in larger quantities it acts as a plant-poison, but whether this is due to the direct action of the manganese itself or to some secondary action on the soil-constituents is not established. A quantity of manganese which is toxic to some plants may be harmless towards others. Thus Aso (*loc. cit.*) finds that barley and oats are not affected by doses of manganese which are injurious to rice, and Kelley states that the soils which do not grow pineapples give good crops of sugar cane. The toxic action is greatest in winter, and if the quantity of manganese present is not excessive the affected plants often recover with the warm weather. The compounds in which manganese plays the part of an electro-negative element are the most toxic, and it appears that some process goes on by which the manganese is converted in the soil from an originally innocuous compound to a more poisonous one, so that its presence is not noticed in the soils for the first year or two. This process is probably one of oxidation, as the higher oxides are found to be more toxic than the lower.

Corroboration of these results has been afforded by the examination of patches of land at Milton (South Coast) in

which barley would not grow. Comparison of the manganese content of this soil and of adjacent land in the same paddock, on which barley grows satisfactorily, showed that in the case of the bad land a higher percentage of manganese was present. The quantities in both cases were again small, but was larger in the bad soil both in the fusion, hydrochloric and citric acid solutions. The amounts soluble in hydrochloric acid were 0·038% in the good soil, and 0·087% in the bad, the amounts soluble in citric acid being 0·034% in the good soil, and 0·062 in the bad. Judging from these results alone, which is perhaps premature, it would appear that couch grass is affected by a proportion of manganese which has no appreciable effect upon barley.

A further case of soil-poisoning probably due to manganese, has been afforded by the examination of samples of soil from the Experiment Farm at Bathurst, on which wheat died down before reaching maturity. The soil on which the crop died was found to contain ·114% Mn_3O_4 (soluble in hydrochloric acid) as against ·026% in soil from the same paddock in which wheat grew normally.

The sample of bad soil was found to contain small fragments (1/10 gram to 1 gram in weight) of a manganiferous iron compound of a black colour and very soft.

OBSEVATIONS ON THE EFFECT OF LIGHT ON THE ELECTRICAL CONDUCTIVITY OF SELENIUM.

By O. U. VONWILLER, B.Sc.

[*Read before the Royal Society of N. S. Wales, November 3, 1909.*]

IT is shown in this paper that on the incidence of light the conductivity of the selenium nearest the surface is increased most, the magnitude of the effect decreasing as the depth below the surface increases. The effect however is not limited to an exceedingly thin surface layer, but an appreciable change is produced in many cases at a depth of several hundredths of a millimetre.

The rate at which the effect falls off with the depth penetrated varies with the nature of the light used, it being found in the cells tested that it is much greater with green light than with red. The sensitiveness of these cells is much less for green than for red light.

These results indicate a greater absorption of green light than of red as was found by A. H. Pfund,[1] and it is shown that the smaller effect produced by the green light is not necessarily inconsistent with the view that the effect produced in any layer increases with the amount of energy absorbed in it.

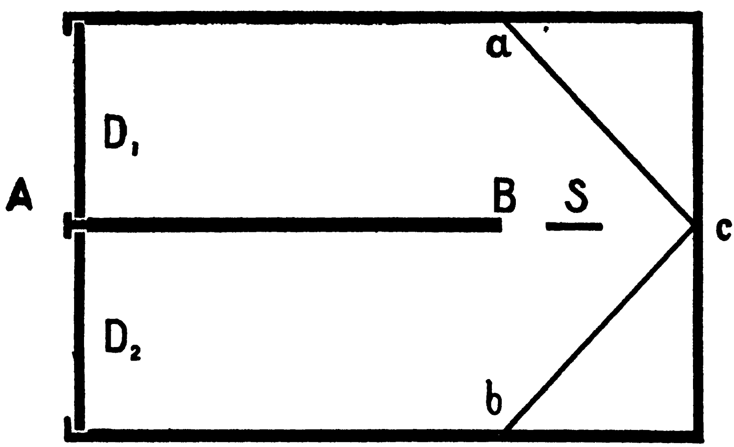
The "cells" employed in the experiments here described were made in the following way. Two platinum wires 0·004 cm. in diameter were stretched on a sheet of mica, being fastened at the ends by means of holes in the mica; the distance between the wires varied from one to four millimetres in different cells. The space between the wires for a length of two or three centimetres was filled with molten selenium spread into a thin layer by means of

[1] Phys. Rev., May 1909.

a glass rod, and the whole cooled rapidly and then heated in an oven to temperatures varying in different cases from 170° C. to 213° C., after which the cell was cooled, sometimes gradually and at others rapidly. The mica at the back of the selenium was then carefully cut away so that light could strike it directly on either surface.

In fig. 1 is shown a horizontal section of a box prepared for the test of such selenium cells. $A\,B$ is a vertical partition running nearly the whole length of the box; $a\,c$ and $b\,c$ are two vertical plane mirrors inclined at 45° to Ac.

Fig. 1.



D_1 and D_2 are two doors, either or both of which may be opened so that light from a source some distance in front of the box may fall on either or both of the mirrors. The selenium cell S is allowed to hang vertically in the plane $A\,B$, the platinum wires being attached to two terminals let through an ebonite piece in the cover of the box, not shown in the diagram. All the surfaces inside the box except the mirrors and the cell were black.

In testing a cell, the source of light was placed at any distance desired in front of the box, and first one door was

opened and the change in conductivity produced by one side of the cell being illuminated was observed. Then the door was closed, and when the conductivity had fallen to its original value the other door was opened and the change produced thereby noted, and then this door being closed and the conductivity having again fallen to the original value in the dark, both doors were opened together and the change in conductivity produced by the simultaneous illumination of the two sides of the cell was observed. On other occasions, one door was opened and after the conductivity had attained its maximum value the other was opened, the first remaining open and the increase in conductivity observed. The doors were then closed, and after the conductivity had fallen to its original value the experiment was repeated, the doors being now opened in the inverse order.

The conductivities were measured by a direct deflection method, a battery of accumulators, the cell and a galvanometer being joined in series; with low resistance cells fractions of the E.M.F. of one accumulator were obtained by means of a potentiometer.

Let (D_1) and (D_2) be the increases in conductivity observed when the doors D_1 and D_2 are opened separately and $(D_1 + D_2)$ the increase when both are opened together; if the effect is limited to a thin surface layer of the selenium we should have $(D_1 + D_2) = (D_1) + (D_2)$.

The cells tested varied considerably in their conductivities and in their sensitiveness to light (in consequence of the different temperatures employed in forming them) but in all tested it was found that $(D_1 + D_2)$ was less than $(D_1) + (D_2)$ the ratio $\frac{(D_1 + D_2)}{(D_1) + (D_2)}$ generally becoming smaller as the intensity of the light increased. In tables I and II are given the results obtained with two cells of which the conductivities were very different.

Cell 12, made 13th April, 1909. Wires $2\frac{1}{2}$ mm. apart; length of wires in contact with selenium $2\frac{1}{2}$ cms; average thickness of selenium $\frac{1}{20}$ mm., (determined by weighing portions after the test had been carried out). In changing the selenium to the conducting form the cell was heated to 213° C. and cooled rapidly. The conductivity in the dark at 18° C. indicated a specific resistance of about one half megohm. The source of light was an 8 c.p. lamp, and the box was screened by a sheet of red glass and a water cell in which the thickness of glass to be penetrated was 9 mm. and that of water 11 mm.

Table I.

Cell 12—Conductivity in dark represented by 9·7 (mean value).

Temperature.	Distance of lamp.	Added Conductivities.			$\frac{(D_1 + D_2)}{(D_1)+(D_2)} = R$
		(D_1)	(D_2)	$(D_1 + D_2)$	
18° C.	100 cms.	2·81	2·35	3·94	$\frac{3·94}{5·16} = ·76$
to	200 cms.	1·60	1·42	2·42	$\frac{2·42}{3·02} = ·80$
19° C.	300 cms.	1·08	0·90	1·70	$\frac{1·70}{1·98} = ·86$

Cell 22, made 26th August, 1909. Wires $4\frac{1}{2}$ mm. apart, length of wires in contact with selenium 3 cm. Thickness not determined, as further tests are in progress with this cell. The cell was heated three times to 190° C. and cooled slowly each time. In the tests with red light the screens were as described for cell 12; in the tests with "green" light, a blue glass was used and a saturated solution of copper sulphate used instead of the water. In the latter case no red or yellow light could be detected after transmission, a fairly bright band in the green and a little blue and violet being seen when examined by a spectroscope.

The red screen permitted the passage of no green or blue light.

Table II—Cell 22, Conductivity in dark represented by 0·80 (mean value).

Observations.	Temperature.	Source of light and screen.	Distance.	Added Conductivities. (D_1)	(D_2)	($D_1 + D_2$)	$\frac{(D_1 + D_2)}{(D_1)+(D_2)} = R$
1	14·4 ° C.	8 c.p. carbon red	100	5·19	6·01	8·50	$\frac{8·50}{11·20}$ = ·76
2	14·2 ,,	,, ,, ,,	150	3·79	4·21	6·02	$\frac{6·02}{8·00}$ = ·75
3	14·5 ,,	,, ,, ,,	300	1·94	2·19	3·20	$\frac{3·20}{4·13}$ = ·77
4	13·9 ,,	,, ,, ,,	600	1·08	1·17	1·80	$\frac{1·80}{2·25}$ = ·80
5	16·8 ,,	1/20 c.p. ,, ,,	600	0·074	0·111	0·175	$\frac{·175}{·185}$ = ·95
6	16·8 ,,	23 c.p. Ta. 'green'	...	0·284	0·418	0·627	$\frac{·627}{·702}$ = ·89
7	14·4 ,,	,, ,, ,,	100	0·153	0·211	0·338	$\frac{·338}{·364}$ = ·93
8	15·4 ,,	,, ,, ,,	200	0·074	0·111	0·181	$\frac{·181}{·185}$ = ·98
9	14·6 ,,	,, ,, ,,	300	0·045	0·073	0·118	$\frac{·118}{·118}$ = 1·00

In observations 5 – 9, Table II, the galvanometer used was 21 times as sensitive as that used in observations 1 to 4 and in all recorded in Table I, the readings obtained being reduced accordingly in the table. An E.M.F. of 2 volts was

used with cell 12, and of 100 volts with cell 22. In observations 1 to 4 with cell 22 the lamp used was an 8 candle power incandescent carbon lamp, in observation 5 a small incandescent carbon lamp of about 1/20 candle power, and in observations 6 to 9 a 23 candle power Tantalum lamp was used. In the case of observation 6 the light was intensified by means of a large concave mirror held at the back of the lamp.

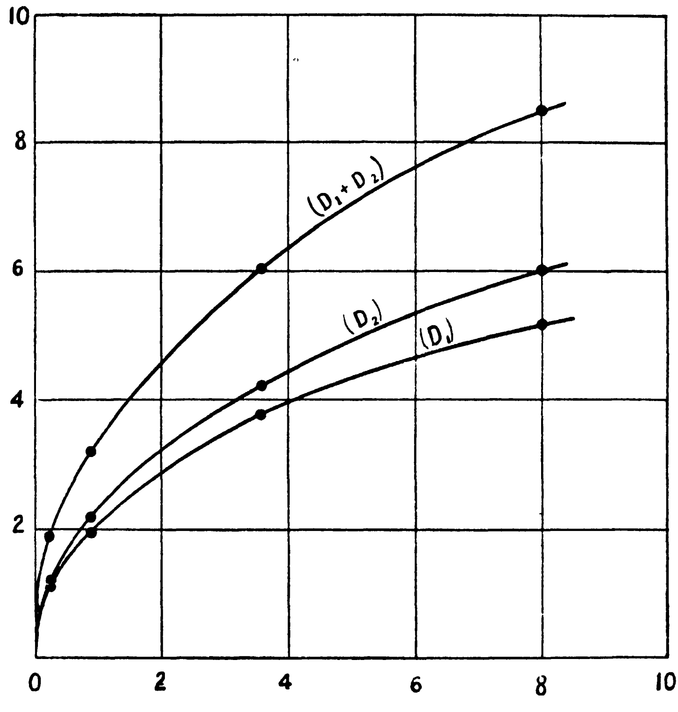
While the absolute conductivity, in the dark, of cell 22 is only about 1/500 of that of cell 12, its sensitiveness is very much greater, an 8 c.p. lamp at a distance of 100 centimetres with the red screen producing an increase of conductivity of more than 1000% when both sides are illuminated, while with cell 12 the increase under similar conditions is only about 40%.

With both cells the ratio $\frac{(D_1 + D_2)}{(D_1)+(D_2)}$ is much less than unity when red light is used. In the case of cell 22 the ratio does not differ much for the first four intensities used, while with cell 12 the ratio shows an appreciable rise as the intensity falls, a similar result being obtained with cell 22 with green light. The effect then seems not to be limited to an extremely thin surface layer but to penetrate more than half-way through the selenium so that the regions affected overlap when both sides are illuminated.

In fig. 2 are drawn curves for Cell 22, showing the relation between the intensities of illumination (abscissæ) and the increases in conductivity, (D_1), (D_2), and $(D_1 + D_2)$, respectively (ordinates), when using red light, the unit intensity being that due to a source of one candle power at a distance of 1 metre. It will be seen that the effect produced when both sides are illuminated with any intensity I exceeds that produced when one side only is illuminated with an intensity $2I$. If there were no decrease in the

effect with the depth penetrated, the whole of the selenium would be affected to the same extent when one side is illuminated and the simultaneous illumination of both sides should produce an effect equal to that obtained when one side alone is subjected to an illumination of double the

Fig. 2.



intensity. The fact that the effect is greater when one side is illuminated than when the other is can be readily understood, the wires being nearer the surface on one side than on the other.

The sensitiveness of the cell is seen to be much less for green light than for red as the intensity of the light was of the same order in both cases while the effects produced were very much greater with red. Similar results were

obtained with other cells tested, but the ratio of the increase in conductivity produced by a green light of given intensity to that produced by a red light of given intensity was not the same for different cells. Of course in neither case was the light used homogeneous; it was desired simply to find whether there was any essential difference in the behaviour of the selenium when the nature of the light varied, and the screens described afforded a means of obtaining lights which differed considerably in colour. It is intended to carry out further and more systematic investigation on the effect when using homogeneous light of various wave lengths.

A number of observations of the rate at which the change of conductivity is produced show further differences in the behaviour of the cell upon illumination by red and green light. Upon the application of light the change in conductivity is not instantaneous, but a definite time is occupied in the attainment of the maximum conductivity, and similarly when the illumination ceases, the fall to the original value occupies a considerable period of time. The rate of change is greatest at the beginning, decreasing as the final value is approached, and when the colour of the light is the same the greater the intensity the greater is the rate, relatively to the total effect, at which the change occurs, both when the cell is illuminated and when it is darkened. On comparing results obtained when using green and red light it is found that the rate of change at the start is much greater in comparison with the total effect produced for green than for red, but that as the maximum value is approached the rise becomes relatively slower with green than with red.

In table III are given results obtained with Cell 22 when illuminated with the red light at distances of 100 cms., 300 cms. and 600 cms., and with the green at 200 cms.

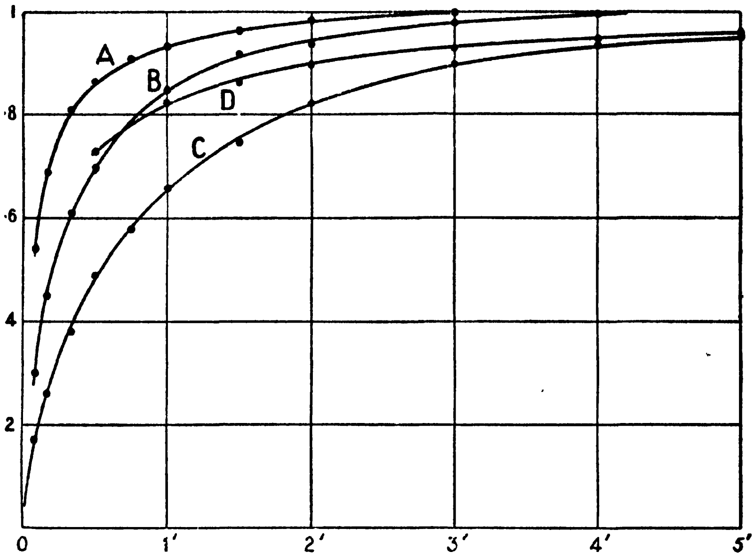
In the first column are given the times from the commencement of exposure to the light, in the second column the actual rise observed with red light at a distance of 100 centimetres, and in the third column these rises are expressed as percentages of the total increase observed. In the remaining colums the corresponding figures for the other intensities are given. In the observations with the green light, a galvanometer the sensitiveness of which was twenty-one times as great as that of the one used with the red light was used; with this galvanometer satisfactory readings could not be obtained in less than thirty seconds after the commencement of the exposure.

Table III

Time.	100 Red.		300 Red.		600 Red.		200 Green.	
5 seconds	2·82 =	54%	0·58 =	30%	0·18 =	17%	...	
10 ,,	3·58	69	·87	45	·28	26	...	
20 ,,	4·20	81	1·18	61	·41	38	...	
30 ,,	4·49	86½	1·36	70	·53	49	1·13 =	73%
60 ,,	4·73	93½	1·65	85	·71	66	1·28	82½
1½ mins.	5·00	96½	1·78	92	·81	75	1·34	86½
2 ,,	5·12	98½	1·83	94	·89	82½	1·39	90
3 ,,	5·18	100	1·90	98	·97	90	1·44	93
4 ,,	...		1·93	99½	1·01	93½	1·47	95
5 ,,	...		1·94	100	1·03	95	1·49	96
7 ,,	...		...		1·08	100	1·52	98
Total rise	5·19		1·94		1·08		1·55	

In figure 3 are plotted curves showing the relation between the increase of conductivity and the time of exposure to light, times, reckoned from the commencement of the exposure, being set out as abscissæ, and the corresponding increases, expressed as fractions of the total increase, as ordinates. *A* is the curve obtained with red light at 100 cms., *B*, with red at 300 cms., *C*, with red at 600 cms., and *D*, with green at 200 cms.

Fig. 3.

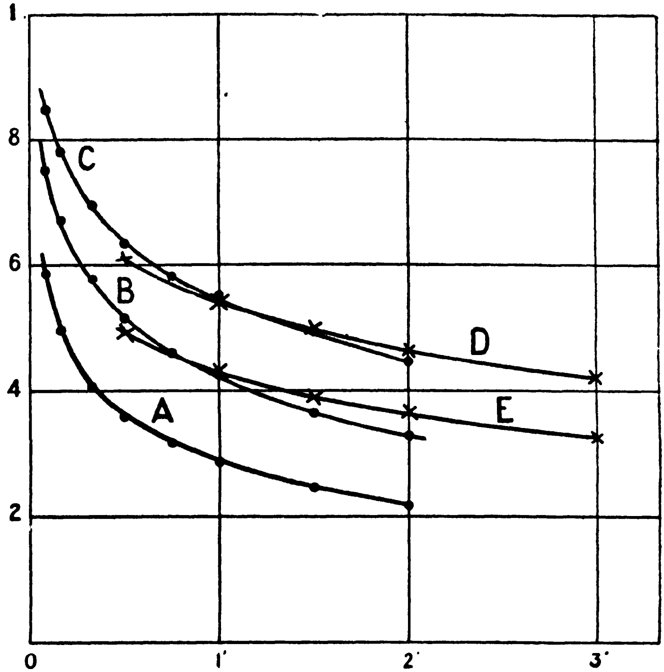


It is seen that the rise is relatively most rapid with the most intense light, the maximum value being attained first with the light at 100 centimetres. With the green light, however the curve of rise differs considerably from those obtained with red light; the fraction of the total increase attained during the first half minute is greater than that with the red light at 300 centimetres, but is decidedly less for the first minute, the difference increasing with the time until at five minutes the rise for the green is practically the same as that obtained with the red at 600.

In fig. 4 curves are drawn illustrating the recovery of the cell after the cessation of the illumination; the abscissæ represent times and the ordinates give the fractions still remaining of the total change produced by the light. Curves are drawn for the same cases as in fig. 3 and in addition that for the more intense green light (observation 6, Table II). *A* is the curve for red light at

100 cms., *B* for red at 300 cms., *C* for red at 600 cms., *D* for green at 200 cms., and *E* for the intensified green light.

Fig. 4.

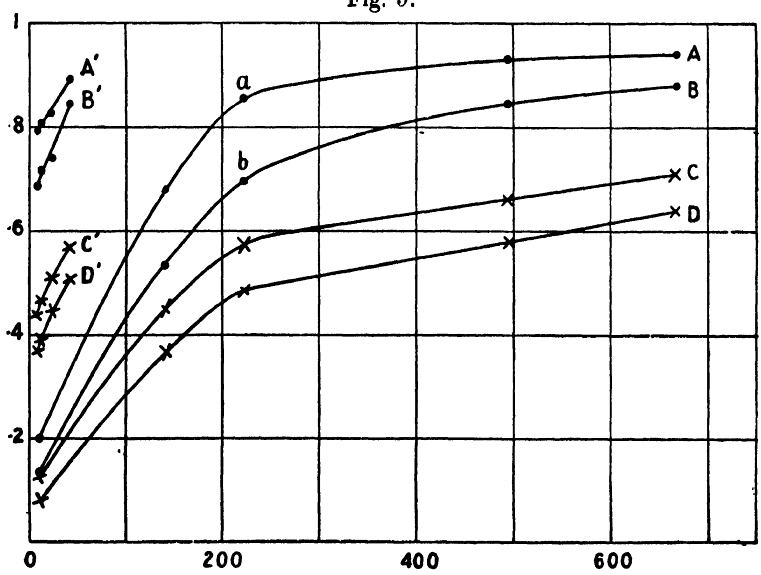


The rate of recovery is seen to be greatest for the most intense light and just as in the case of the rise of conductivity upon exposure to the light, the curves for green show a more rapid rate of fall at the start, becoming slower relatively to the red as the time advances. This however is due in part to the fact that the duration of the exposure when using green light was longer than with red, the exposure being continued in all cases until the conductivity was practically steady for several minutes. Each curve represents the mean of several trials, and with red light the exposures lasted from five to ten minutes, and with green from ten to twenty minutes. The differences in the rates

of fall after different times of exposure in any instance were very small however, so that the difference in the behaviour of the cell with red and green light would be practically the same for exposures of equal duration, provided that the maximum value had been obtained in each case.

In fig. 5 curves are drawn illustrating the results obtained with cell 22, in a different manner. As abscissæ are taken the total increases in conductivity produced by exposure to light of different intensities, expressed as percentages of the conductivity in the dark, and as ordinates the fraction of the total change produced in some given time. Curves A and B give the fractions of the total rise produced in 60 seconds and 30 seconds respectively, and curves C and D give the recovery after the illumination has ceased for the same times, red light being used in all cases. For example, the point "a" shows that when the light was such that it produced a change in conductivity equal to

Fig. 5.



222% of the initial value, ·855 of that change occurred in 60 seconds, "*b*" shows that ·695 of the change occurred in 30 seconds and so on. When green light was used the corresponding curves are given by A' B' C' and D' respectively. For the curves A, B, A' and B', the figures obtained when one side only (D_1) is exposed to the light are taken and for the curves C, D, C' and D' the results obtained after both sides have been exposed are used.

These curves show in a marked manner the difference in the initial rates of rise and fall when using light of different colours and the point already noted, the relatively slower rise towards the end with green is also illustrated; for example with a certain red light we see that 69½% of the rise occurred in 30 seconds, and with a certain green light 68½% occured in the same time, but in 60 seconds 85½% of the total change had been produced with the red and only 79% with the green; similar results are noticed in the curves for the falls of conductivity.

This relatively slower rise towards the end is shown in Table IV in which the rises observed after different durations of exposure are given for different intensities of illumination.

Table IV.

Colour.		Distance of Light.			
		100 cms.	200 cms	300 cms.	600 cms.
Red	Rise in 3 mins	5·18	...	1·90	0·97
	,, 5 ,,	5·19	...	1·94	1·03
	Difference ...	·01	...	·04	·06
	Total rise ...	5·19	...	1·94	1·08
Green	Rise in 3 mins.	3·47	1·72	1·10	
	- ,, 10 ,,	3 82	1 94	1·24	
	Difference ...	·35	·22	·14	
	Total rise ...	3·83	1·94	1 24	

The readings with green light are to be divided by 21 in order to be on the same scale as those with red.

With red light the rise between the third and fifth minute is greatest for the weakest light, or the conductivity is still altering appreciably here when it has attained a practically steady state with the strongest illumination, but with green light the greatest rise between the third and tenth minute of exposure is obtained under the strongest illumination and it is found that the rise ceases to be appreciable at about the same time for all the intensities used in the tests with green light.

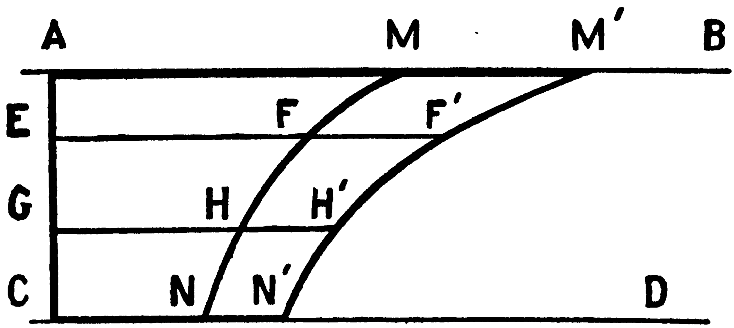
Miss Louise McDowell in a paper on the Electrical Properties of Selenium[1] describes some experiments on the rate of rise and fall of the conductivity on exposure to light of different colours and intensities, obtaining results similar to some of those here described. Miss McDowell suggests that the differences obtained may be due to differences in the powers of penetration of light of different colours. A. H. Pfund[2] found that in the visible spectrum the absorption by conducting selenium increased as the wave length of the light decreased. The results here described seem to show that the effect produced by the light falls off much more rapidly with the depth penetrated when green light is used than when red is, if we may assume that the time taken in the production of the change in conductivity in any small portion of the selenium depends on the magnitude of the change, being less for large changes than for small ones.

For let $A B$ fig. 6, represent the upper surface of the selenium upon which light is incident, and $C D$ the lower surface; let AM represent the total change in conductivity in the surface layer, and $E F$, $G H$, $C N$, the changes in layers at depths $A F$, $A G$, $A C$. The change is produced most rapidly at A and is slowest at C. Now let the intensity of the light be increased so that $A M'$ $E F'$ $G H'$ and $C N'$ represent the change produced at A, E, G, C. Each of

[1] Phys. Rev., July 1909. [2] Phys. Rev., May 1909.

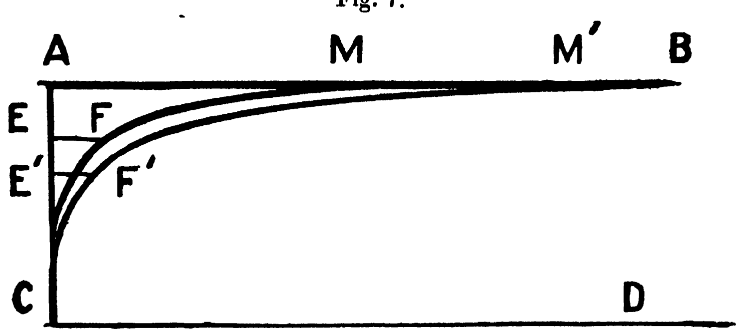
these changes is produced more rapidly than the change at the corresponding point under the weaker illumination, so that the final steady value will be reached in a shorter time with the stronger illumination than with the weaker.

Fig. 6.



Now suppose that the effect falls off much more rapidly as the depth increases as in fig. 7, so that it is negligible before the lower surface is reached. Here if $A\,M$, the effect at the upper surface is equal to that in the former case (fig. 6), the change in the surface layer will occur with equal rapidity in the two cases, but in lower layers, as $E\,F$, the effect is much less and will occur more slowly in the latter example, so that the total effect produced by the light will be less than before but the initial rate of rise almost as great, and, in comparison with the total change produced, greater than

Fig. 7.



in the first case, and at a time when the change had been completely produced in the first case it would be still going on in the second. If in the case of fig. 7 the illumination were increased so that $A M'$ is the effect at the surface, the initial rate of rise and the total effect would both be increased, but the final value would not be attained any sooner than before, since corresponding to any layer E with a change $E F$ with the weaker light there is a layer $E,'$ with a change $E' F'$ equal to this, with the stronger illumination, both these changes taking the same length of time to occur, and unless the intensity is so great that an appreciable effect is produced at the lower surface, the time occupied in getting to a state where no measurable change occurs will be no shorter with strong illumination than with weak.

Now in the observations given above on the rates of rise of conductivity upon exposure to red and green light, it is seen that under the action of red light the selenium behaves as though the effect varied with the depth below the surface as in fig. 6, and under the action of green light as though it varied as in fig. 7. The results obtained when the two surfaces were illuminated separately and together confirm the view that the effect with green light falls off more rapidly as the depth penetrated increases, for in a case such as that of fig. 7, the increase in conductivity obtained when both sides are illuminated would be almost equal to the sum of the increases obtained when the sides are separately illuminated, as there is practically no overlapping of the regions affected, whereas in the case of fig. 6, where considerable overlapping occurs, the illumination of both sides produces an effect considerably less than the sum of the changes produced when the sides are separately illuminated.

That the rapidity with which the effect is produced should increase with the magnitude of the effect might be

expected. We may imagine the selenium to be made up of molecules, some of which have temporarily lost an electron, there being as many free electrons as there are molecules which have lost an electron, and the conductivity being proportional to the number of free electrons. The free electrons will often combine again with a molecule which has lost an electron, the rate of combination being assumed to be proportional at any instant to n^2 where n is the number of free electrons at that instant, and the rate of production of fresh electrons may be regarded as a constant depending on the density of the molecules, their relative position, temperature, etc.

The absorption of energy may well be supposed to increase the readiness of the molecule to part with an electron, and so, in such a case there would be an increase in conductivity, the rate of change of n being given by

$$\frac{dn}{dt} = b - an^2 \dots\dots\dots\dots(1)$$

b being the rate of production and an^2 the rate of combination; b is equal to an_1^2, n_1 being the number of free electrons when a steady state is attained. In the dark b has a value $b_0 = an_0^2$, n_0 being the number of free electrons in the dark. The greater the increase in b the more rapidly does the change occur, as is easily seen from (1).

A. H. Pfund investigated the sensitiveness of a cell for light of different colours and found the maximum sensitiveness with light of wave length 700 $\mu\mu$, *i.e.*, in the red. It might be expected that the maximum effect would be produced by the light which is most strongly absorbed, and Pfund advances a theory to explain why this is not so. He suggests that the effect is limited to an extremely thin surface layer the thickness of which is of the order of 10^{-6} cm. for blue light, and that though this film is made up of material which possesses a high conductivity when

light shines on it, its apparent resistance is high on account of the thickness being less than the length of the free path of the conducting electrons in the material, whereas when light of longer wave length is used the absorption being less, the thickness of the layer affected is much greater and though the specific conductivity is less than when illuminated by blue light, the observed increase in conductivity is greater on account of the thickness of the layer affected exceeding the free path of a conducting electron. The values found by Pfund for the absorption of light seem to indicate that it would be almost completely absorbed in an exceeding thin film, but as he himself points out, his readings may be considerably in error on account of his being able to obtain but one film and so not being able to correct for surface losses, and it must be remembered that the electrical properties of conducting selenium depend greatly on the method employed in preparing it, and it is not improbable that the optical properties also depend on this and the numerical values of the coefficient of absorption deduced from Pfund's observations may differ considerably from those which hold for the selenium in the cells used. Certainly the experiments described here seem to show that the layer affected is much thicker than is assumed by Pfund while they also show that the absorption of green light is greater than that of red as Pfund found.

The fact that the sensitiveness of a cell is not a maximum for light of that colour which is most strongly absorbed by the selenium can be explained on another theory.

Let us suppose that the increase in conductivity in a thin layer of selenium depends on the absorption of energy in that layer, increasing as the amount of energy absorbed increases, and let I_0 be the intensity of the light incident on the surface, and a the coefficient of absorption of the

light; at a depth x the intensity is $I_0 e^{-ax}$ and the energy absorbed in a thickness dx is $a\, I_0 e^{-ax}\, dx$.

If e_x is the effect produced at a depth x we may assume

$$e_x = f\,(a\, I_0 e^{-ax})$$

and the total effect produced is $E = \int_0^X f\,(a\, I_0 e^{-ax})\, dx$

X being the thickness of the selenium.

The effect is not proportional to the absorption of energy, for if it were the increase in conductivity would be proportional to the intensity of the light incident on the cell, whereas it rises more slowly than the intensity as is seen in fig. 2.

Let us assume tentatively that the effect produced is proportional to the nth power of the energy absorbed where $n < 1$.

$$\text{Then } E = \int_0^X p\, a^n\, I_0^n e^{-anx}\, dx, \text{ (p being a constant)}$$

$$= \frac{p\, a^{n-1} I_0^n}{n} (1 - e^{-anX})$$

If X is very small $E = p a^n\, I_0^n X$, so that the greater the value of a, the coefficient of absorption, the greater is the effect produced, that is the cell has maximum sensitiveness for the light which is most strongly absorbed.

If X is infinitely great $E = \dfrac{p a^{n-1} I_0^n}{n}$ and as $n < 1$, the smaller a is the greater the effect; that is the light which is least absorbed produces the maximum effect if n is the same for all intensities.

For intermediate thicknesses the effect will be a maximum for some value of a which is neither the maximum or the minimum, but which would seem to depend on the thickness, the value of a for which the effect is a maximum being greater the thinner the layer of selenium in the cell. With many of the cells tested the increase in conductivity

is approximately proportional to the nth power of the intensity of the light, n being about 0·4, but decreasing with increasing intensities. On this assumption of the relation between the light absorbed and the effect produced, the intensity of the light falls off more rapidly than the effect as the depth penetrated increases. For instance, if $n = \cdot 4$, at a depth at which the intensity of the light is 1/1000 of its value at the surface, the effect produced is $(1/1000)^4$ or 1/16 of its value at the surface, so that the effect is still appreciable at depths where the intensity of the light is extremely small.

It is not claimed that this theory is correct, some of the assumptions made are certainly wrong—n is not a constant for instance, but it is given in order to show that a selenium cell does not necessarily possess maximum sensitiveness for light of the colour which is most strongly absorbed. Further experiments are in progress which it is hoped will give more information on the subject.

The experiments described in this paper were carried out in the Physical Laboratory of the University of Sydney.

RIGID STABLE AEROPLANES.

By L. Hargrave.

[With Four Drawings.]

[*Read before the Royal Society of N. S. Wales, December 1, 1909.*]

The rapid progress of aeronautics is hampered and delayed by the want of a method of ensuring automatic longitudinal and transversal stability. To remove this obstacle I repeat or refer to such knowledge as has come under my notice, my own previously expressed views, and also describe and exhibit my last experiments and explain their novelty and utility.

We find that Dr. Thomas Young[1] proved in 1800, that a certain curved surface suspended by a thread approached an impinging air current, instead of receding from it. This surface was a reverse curve like Fig. 16, Plate XVII, this Journal, Vol. XXXI, 1897.

This curve has been worried over and tried by many kite and flying machine men with no appreciable success, or it would be used in all the flyers of to-day. Then there are my papers, " On the Cellular Kite,[2] and on "Aeronautics."[3] Then we have the all important article by W. R. Turnbull, on " Form and Stability of Aeroplanes."[4]

A careful reading of the articles and matter referred to will make it clear that the road was paved with velvet and I had only to dance along it and make

(1) One section of a multiple planed flying machine with reverse curves and which possessed automatic stability.

[1] Progress in Flying Machines, by O. Chanute, p. 9.

[2] This Journal, Aug. 5, 1896, p. 144. [3] *Loc. cit.*, June 1, 1898, p. 55.

[4] Scientific American Supplement, No. 1726, Jan. 30, 1909.

(2) Design and make a suitable type of motor.

(3) Make a working model.

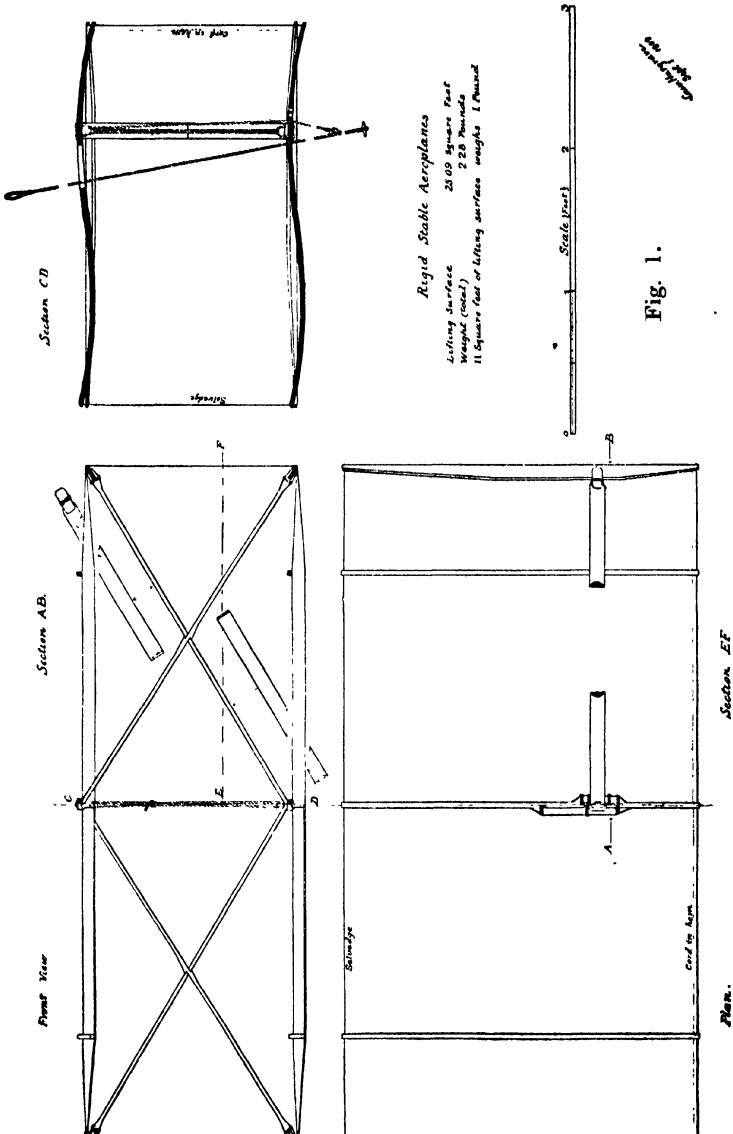


Fig. 1.

The scale drawing (Fig. 1) shows in every detail the method of combining two reverse curves so that they shall be permanently stable, not only longitudinally but transversely. It shows how rigidity of form is maintained without the use of diagonal ties of any sort. It shows how any number of sections may be united to support any weight. It shows that the limit of weight that the ordinary monoplane or bi-plane soon reaches, is easily passed by the substitution of arithmetical for geometrical progression in the proportions of the lifting areas. It shows the futility of applying reverse curves to the ordinary flying machines if they are rigidly attached thereto, *because* the combined *inertia* of motor, passengers, heavy struts, stays, etc., effectually *masks* and prevents the *instant* action of the light reverse curves in automatically adjusting themselves to every gust and tremor in the air.

The type of motor most suitable for driving rigid stable aeroplanes is the two-stroke spring engine (Fig. 2 *a*, *b*). This

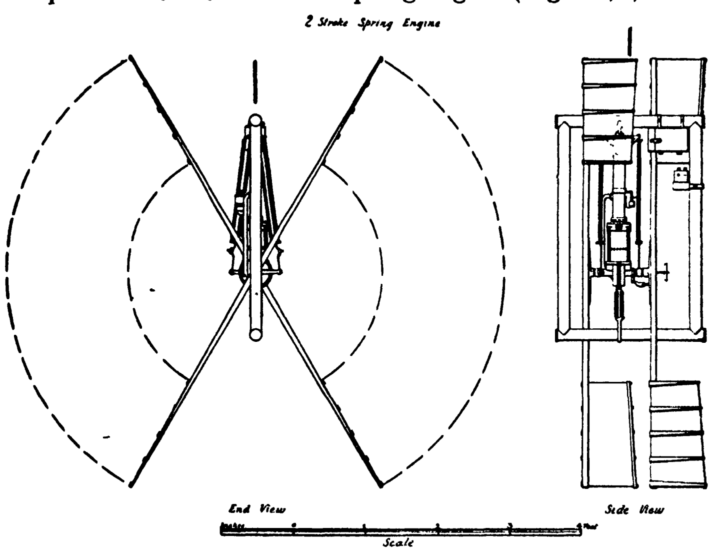


Fig. 2 *a*.

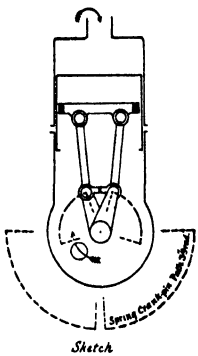


Fig. 2 *b*.

scale drawing shows two views of the first one I have made; it was designed to flap the four wings 120° for each explosion. Numerous errors in the strength and proportion of its various parts cannot be altered without beginning anew. The sketch shows the wing arc had to be reduced to 90° to suit the exhaust ports and compression space; it also shows how the main cranks and spring cranks are arranged so that the curve of the torque produced by the spring tension, shall, when plotted on the theoretical indicator diagram, fall about midway between the explosion and compression lines.

This is the cycle of events. The wings are moved several times by hand to charge the crank chamber with mixture, which flows on through the external pipe and inlet valve to the compression space and cylinder. The hands are then withdrawn from the wings, and the springs at once flap the wings and in addition compress the cylinder full of mixture into the compression space, and also recharge the crank chamber. Contact is made, the compressed mixture explodes driving down the piston, flapping the wings, storing power in the springs for the up stroke, and compressing the mixture in the crank chamber. This is all, and it is repeated till there is a miss-fire or the effects of bad workmanship stop the engine.

The small working model (Fig. 3) shows an adaptation of means to ends, and is thought to be more significant and convincing than the tabulated results of an elaborate whirling machine would be at this particular juncture. You have seen here aeroplanes with absolutely no extensions fore and aft of their canvas, that maintain automatic stability

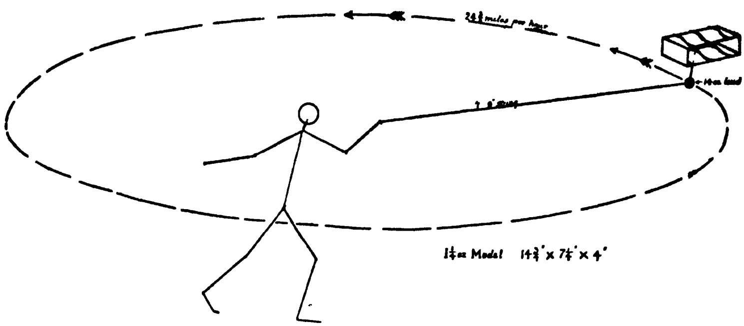


Fig. 3.

both longitudinally and transversely under most trying circumstances. You have seen how the exact work of W. R. Turnbull was not of the slightest use to aeronautics till it could be combined with the other essentials of flying. You have observed that all flying machines that have been described previously embody scaffold-like structures forward or aft to hold movable surfaces requiring constant attention, and this fact alone indicates that the art as practised to-day is at the stage it was on April 12, 1890, as per our Journal of that date. You also understand, as a matter of pure mechanics, that the air is permeated with gusts and tremors of the most rapid and conflicting nature, and that the weight of a body that has to move through it and preserve a uniform aspect, must have a minimum of inertia so that it can instantly adapt itself readily to ever changing conditions. Common sense steps in here and says: *Separate the parts you want to be mobile from the parts you want to be inert.* You have seen the result, and I know many have the skill to apply it.

This is the very heart of the invention, and in the present state of the industry cannot fail to be understood. I am advised that it is, or was, patentable before it was exhibited here, but mature thought shows the perfect impossibility of collecting revenue from the consumers who are the practicers of the art I wish to advance and not to retard.

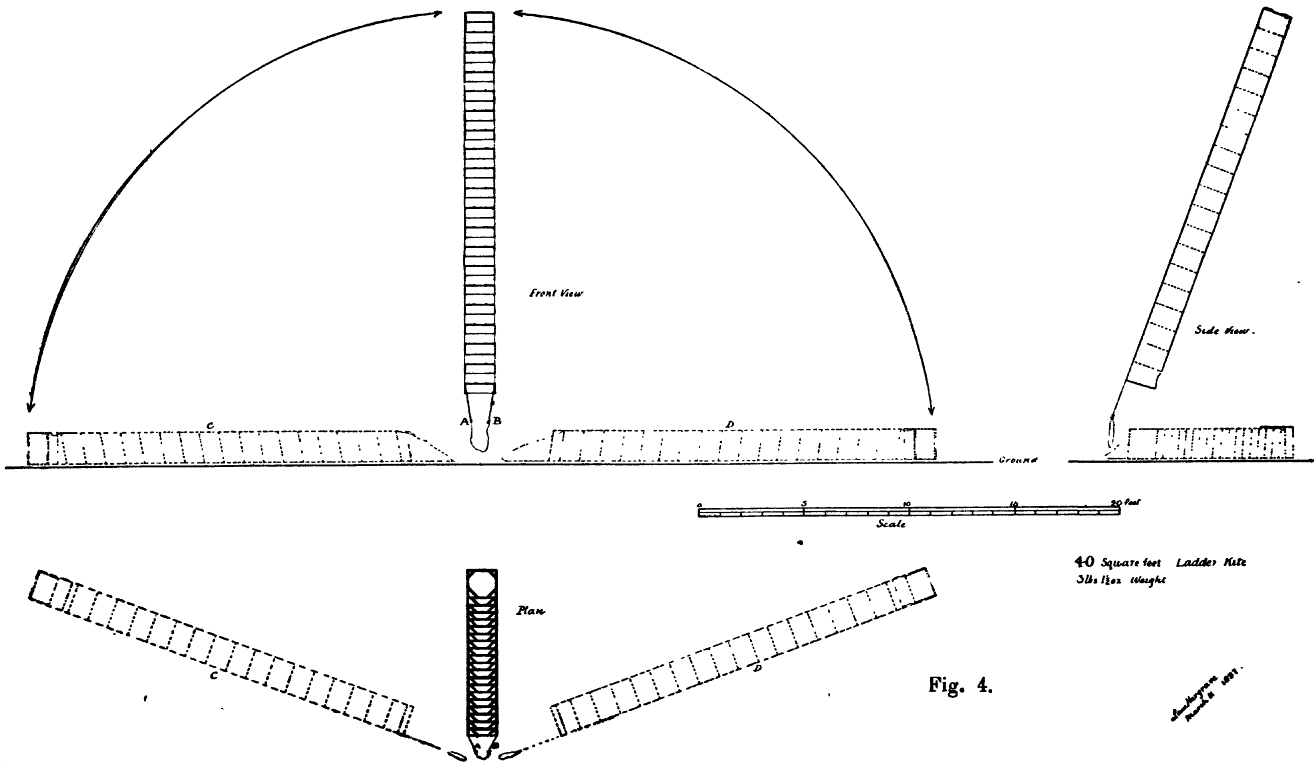

Front View
Side View.
A
B
C
D
Ground
0
5
10
15
20 Feet
Scale
Plan
40 Square feet Ladder Kite
3lbs 1½oz Weight

Fig. 4.

If the string and weight are swung without the rigid stable aeroplane, the string can only describe a blunt cone with the apex upwards. When the aeroplane is tied to the weight, the apex of the cone is downwards, indicating that the aeroplane at that velocity is lifting more than the weight. A great increase of velocity adds enormously to the weight on the aeroplane, as the weight is trying to flatten the inverted cone.

Used as kites, these rigid stable aeroplanes are superior to the very best cellular kites I can make; they are lighter, pull harder per square foot, attain a greater angle of elevation, and have fewer parts. When their qualities become known, the two-celled kite will be considered a barbarism of the past. The ladder kite that was experimented with in 1897 (Fig. 4) is a very light and compact form of multiplane lifting surface. The twenty planes are 1 foot $5\frac{1}{3}$ inch square; they are spaced one foot apart. The two highest planes are strutted into the box form; the rest of the side surfaces are quite loose and only tightened by the lift of the planes. The best way to fly this kite is to lay it out on the ground in either of the dotted positions shown on the plan. Pull a little on the string that is not lying on the ground, thus squaring the rhomboidal shape of the kite, and it will at once assume the upright position. Similarly by pulling either string the kite will lay itself down without damage on the side that it is pulled. If you pull *A* the kite lies down at *C*. If you pull *B* it lies down at *D*. The kite, when on the ground, does not roll away to leeward as one might expect.

NOTE ON THE NEW WIECHERT SEISMOMETERS AT RIVERVIEW COLLEGE, SYDNEY.

By Rev. E. F. PIGOT, S.J.

[With Plates XV, XVI, XVII.]

[*Read before the Royal Society of N. S. Wales, December 1, 1909.*]

THE following short account of the recent installation of earthquake instruments at St. Ignatius' College is brought before this Society mainly owing to the kind encouragement of Professor Pollock, who has considered the matter of sufficient general interest to warrant its being brought under the notice of the Society. I have been further induced to do so by the kindly interest shown by his distinguished colleague on the professorial staff of the University of Sydney, Professor David, and by Dr. Woolnough, both of whom, together with Professor Pollock, inspected the instruments at the College shortly after their erection, and joined him in a cordial expression of approval. I should like to take this opportunity of recording my obligation to the Director of the Geophysical Institute of Frankfort, Dr. Linke, formerly Director of the Observatory at Samoa, and especially to his successor, Dr. Angenheister, for their valuable assistance to me when contemplating this installation. During my stay of over three weeks at Samoa last year, the latter gave me not only every facility towards the object of my voyage, viz., the detailed study of the instruments, the methods for the reduction of the records, etc., but also day after day much of his own valuable time.

I have been sometimes asked: what originated the idea of starting a Seismological Observatory at Riverview? The answer is simple. Having been for some time on the staff of the Observatory at Zi-ka-wei (Siccawei), near Shanghai,

where the French Missionaries, like their Spanish confrères at Manila, Philippine Islands, have carried on for many years scientific work of a high order in the several departments of Astronomy, Meteorology, Terrestrial Magnetism, and Seismology, and my interest in the study of the last named branch having been aroused in a special way by the fine records of the Californian and Chilian earthquakes of 1906, obtained at both of these observatories by very up-to-date seismographs, it was natural enough that on my return to Sydney shortly afterwards, my plans for a College-observatory should turn in this direction, amongst others. I was well aware of the valuable work done for many years in Australasia, as part of a world-wide network of seismograph stations, by the standard instrument adopted by the British Association and designed by the veteran English seismologist, Professor John Milne, and I had already had the opportunity of studying its performance at close quarters and appreciating its merits. But the very fact of the Milne instrument being already for some time in operation in Sydney, as well as in Melbourne, Perth, Wellington and Christchurch (the Adelaide one, the best of the six, has only begun work this year), and on the other hand, the high praise given during the last few years by very competent authorities in various countries to the performances of some of the more recent Japanese and German seismographs, induced me to adopt one of the latter types of instrument, for the registration of seismic wave-movement here in Sydney.

It has been my wish that this registration should be of the highest accuracy and sensitiveness, and moreover complete, giving the three rectangular components (vertical and two horizontal) and not merely one, and that the records should be used as contributions from New South Wales to the international seismological research-work so actively

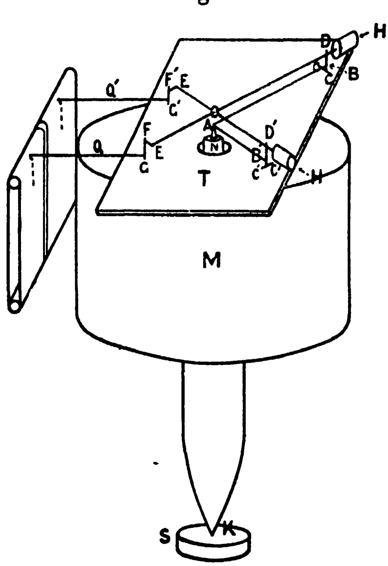
being carried on during the last few years according to more rigorous scientific methods. And if also, quite apart from their registration of earthquake movements properly so called, the instruments, used as clinographs rather than seismographs, might possibly in the course of years, reveal slow progressive tilting, the ascertained direction of which would throw some light on the nature of any geotectonic movement of the Australian Cordillera and the bed of the western Pacific, they would, I think, have an additional usefulness. I eventually decided to commence with the two instruments I am about to describe, which were erected in February last, immediately on their arrival from Germany, in the seismograph-cellar specially built for them in a secluded spot in the college grounds, far from any artificial source of vibration or disturbance. Both of these seismometers are designed by Professor Wiechert, of the Geophysical Institute (and University) of Göttingen, one of them registering the two components (N.S. and E.W.) of the horizontal movement, the other the vertical component, of the earth-waves.

And first, as regards the horizontal seismograph. It is fully described in Professor Wiechert's original paper, published in the "Physikalische Zeitschrift," 4th year, No. 28, pp. 821 and seq.[1] He calls it an "astatic pendulum of high sensibility for the mechanical registration of earthquakes." He adopted a mode of suspension differing completely from those in general use. While the Italian school of seismology, as represented by the instruments of Professors Vicentini and Agamennone, has favoured mainly, though not exclusively, the "vertical" type of pendulum, a heavy bob (the so-called "steady-mass," "dead mass," or "stationary-mass") suspended by stout wire, the non-

[1] A detailed account of it is also to be found in the "Annuaire. Astronomique" for 1907, published by the Royal Observatory of Belgium, p. 470 and seq

Italian instruments of more modern date have been mostly of the "boom-pendulum" ("horizontal" or "conical" pendulum) type, in some form or other, the underlying principle of which is due to the German physicist Zöllner. Such are the seismographs designed (or modified) by Rebeur-Paschwitz, Ehlert, Milne, Omori, Hecker, Grablowitz and others. The Wiechert instrument is an *inverted* pendulum, the centre of gravity being vertically *above*, instead of below, the point of support, stability of equilibrium within certain limits being obtained by steel springs of very high quality, on the elasticity of which partly depends the period of vibration of the whole pendulum.

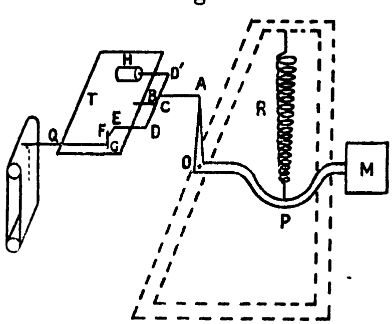
Fig. 1.



From the accompanying diagram (fig. 1) some idea may be formed as to the mode of action of the more essential parts of the instrument. The large stationary mass M, weighing 1000 kilograms (1 ton) is moveable about a point K, where it is supported by an iron base S resting on a concrete foundation. At its upper part, it has a projecting pillar N, passing through a hole in the table T, which is rigidly fixed to the concrete block below. The two rods $A\,B$, $A\,B'$, placed respectively in the N.S. and E.W. azimuths, transmit the corresponding components of the oscillations of the point A to the recording apparatus in the following way. The rod $A\,B$ is connected at B with a vertical lever $C\,C\,D$, moveable about on axis $C\,C$, with

which axis is connected the equilibrating steel spring referred to above; the point *D* will therefore repeat on a large scale the movements of *A*, in the direction *A B*. *D* is connected on one side to the piston of the damping-cylinder *H*, by means of which the pendulum is rendered almost aperiodic or "dead-beat" (a point of vital importance now universally recognized, and first insisted upon and introduced into instrumental seismology by Professor Wiechert), and on the other by means of the rod *D E* with the arm *E F* and the vertical axis *F G*: the oscillations of *D* are thus communicated in a highly magnified form to the platinum stylus writing on smoked paper at the extremity of the arm *Q*.

Fig. 2.



In fig. 2, another rough diagram, is illustrated the action of the vertical seismometer, the letters indicating the same parts as in the above. The "stationary-mass" *M* in this case weighs 80 kilograms and is attached to one end of a lever *O M* whose fulcrum is at *O*, the weight of *M* being antagonised by a helical steel spring *R*, applied at the point *P*. Thus the vertical component of the earth-movement in an earthquake will affect and alter the equilibrium-position of *O M*, which will oscillate in a vertical plane, the oscillations being communicated by the arm *O A* and rod *A B* to the lever *D D'*, moveable about *C* in a horizontal plane. The ends of this lever, *D* and *D'*, are connected in a manner quite similar to that already described for the horizontal components, and transmit the movement on the one hand to the damping-piston at *H*, and on the other to the record-

ing stylus on the clockwork-driven drum carrying the smoked paper.

The seismograph last described, is of special interest from the fact of its being, so far as I am aware, the only Vertical Seismograph in Australasia actually in use. One reads and hears from time to time somewhat disparaging criticisms as to the performances of vertical seismographs, and certainly with the older models so much was left to be desired as quite to justify such criticisms. But without over-praise of the Wiechert Vertical Seismometer, I think that its records will before long do much here in Australia, as they have done in Europe, to alter the unfavourable opinion regarding this class of instrument, and make it to be considered as an important auxiliary to its more favoured companion and fellow-worker in a well-equipped geophysical observatory—the Horizontal Seismograph.

NOTES ON GOULBURN WATER WITH SOME EXPERIMENTS ON ITS CLARIFICATION.

By G. J. BURROWS, Caird Scholar, University of Sydney.
(Communicated by Prof. J. A. SCHOFIELD.)

[*Read before the Royal Society of N. S. Wales, December 1, 1909.*]

THE suspended matter in the water of the Wollondilly River, from which the Goulburn water supply is derived, is in a very finely divided condition, taking an extremely long time to settle and being very difficult to filter. In some circumstances, *e.g.*, after heavy rain, the present storage and filtration arrangements do not admit of the complete removal of this suspended matter, and the water is supplied to the town in a turbid condition. The following experiments were undertaken primarily with the object of ascertaining the minimum amount of clarifying agents required on a laboratory scale to give a clear water in a reasonable time. The samples were taken by the water works engineer from the reservoir into which the water is pumped from the river. The first sample, taken on October 14th, 1908, was almost clear, and therefore not suitable for clarifying experiments. Pending the arrival of a turbid sample this water was analysed with the following results:

Total solid residue	22·1	parts per 100,000
Loss on ignition...	11·2	,, ,,
Chlorine	3·9	,, ,,
Organic ammonia	·058	,, ,,
Free ammonia	·017	,, ,,
Hardness, temporary	8·0	,, ,,
Hardness, permanent	7·5	,, ,,
Nitrogen as nitrates	·006	,, ,,

Nitrogen as nitrites ...	...	·02	parts per 100,000
Sulphur trioxide (SO_3)...	...	1·35	„ „
Magnesium oxide (MgO)	...	4·25	„ „
Oxygen absorbed in 15 minutes		·144	„ „
Oxygen absorbed in 4 hours ...		·192	„ „

The solid residue before ignition had a strong organic odour and a brownish colour.

Since the organic and free ammonia appears excessive in this analysis a sample from another bottle was tested, with the following results :—

Organic ammonia	...	·014	parts per 100,000
Free ammonia ...	...	·023	„ „
Total ...	...	·067	„ „

Experiments with Clarifying Agents.—Experiments were next tried with clarifying agents: lime, alumino-ferric (commercial aluminium sulphate) and ferrous sulphate, to test the effect on the ammonia and on the hardness. As the water had been standing for a month since the last determination of ammonia this was redetermined; the organic ammonia had decreased and the free ammonia increased, the total being very nearly the same. These figures are given in Table I. 600 cc. of the water were taken in each case, the clarifying agent added, allowed to stand one night, then filtered and analysed.

Table I.

Substance added.	Ammonia.						Hardness.					
	Organic		Free.		Total.		Tempry.		Permnt,		Total	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Ex. I. ·0087 grm. CaO	·039	·012	032	·027	·071	·039	8	6 5	7·5	6·5	15·5	13·0
II. ·0101 „ AlFe	„	·018	„	·034	„	·052	„	6	„	6·5	„	12·5
III. ·101 „ AlFe	„	007	„	044	„	·051	„	3	„	10·5	„	13·5
IV. ·02 „ $FeSO_4$	..	·01	„	·044	„	·054	„	7	„	11	„	18·0

In all cases there was a considerable reduction in the amount of organic ammonia and an increase in the amount

of free ammonia, the total ammonia showing only a slight reduction, except in Ex. I, with lime, which showed a considerable reduction from ·071 to ·039. This was possibly owing to the slow filtration, one and a half hours being consumed. In each of the other cases the time taken was about half an hour. The total hardness was not affected to any extent.

Second Sample of Water.—Another sample of water was collected on February 7th, 1909. This was very turbid, being collected after heavy rains.

Hardness—Temporary	...	4	parts per 100,000
,, Permanent	...	16	,, ,,
Total ...	...	20	,, ,,

In this estimation the heavy sediment was allowed to settle and the still turbid water then poured out.

Experiments on Clarification.—The agents tried were lime, alumino-ferric, ferrous sulphate, and mixtures of these. 200 cc. stoppered measuring cylinders $10\frac{1}{4}$ inches in height were used for these experiments. Large quantities (·5 grams to 200 cc.) of the three clarified the water very quickly. Smaller quantities (·1 gram) of each indicated that alumino-ferric was the best agent; this quantity of alumino-ferric clarified the water in a few minutes, whereas the same quantity of the other two (lime and ferrous sulphate) required several hours. Mixtures of the three reagents were also tried, but these were inferior to the alumino-ferric alone.

Using quantities of alumino-ferric and slaked lime, containing approximately the same weight of element (·0054 grams) *i.e.*, ·01 gram $Ca(OH)_2$ to 200 cc. of water and ·0342 grams alumino-ferric to 200 cc. of water, it was found that the cylinder containing the alumino-ferric settled in eight minutes, the other did not settle in six hours but was fairly

clear the next morning after eighteen hours. Even using larger quantities, up to ·1 gram, of slaked lime, the water did not become as clear as that obtained by using ·0342 grams of alumino-ferric.

Having decided that alumino-ferric was the best clarifying agent, the minimum quantity required to clarify the water in twenty-four hours was next determined; this was found to be ·015 grams to 200 cc. This amount clarified the water almost completely in two hours, the water being perfectly clear after twenty-four hours. The ammonia and hardness were determined after clarifying 1,000 cc. of water in this manner allowing the water to stand eighteen hours, with the following results:—

Ammonia.						Hardness.					
Organic.		Free.		Total		Temporary.		Permanent.		Total.	
Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
·066	·029	·053	·091	·119	·120	4	nil	16	20	20	20

The organic ammonia is decreased and the free ammonia correspondingly increased, the total remaining the same. The permanent hardness is increased and the temporary decreased to the same amount, the total remaining the same.

Cost of Clarifying the Water.—Assuming that the population to be served by the water supply is 15,000 and the consumption per head at 40 gallons per day, the total supply per day would be 600,000 gallons. The amount of alumino-ferric required at the rate of ·015 grams per 200 cc. is 73 tons per annum. The price of alumino-ferric in England is about £2 10s. per ton, and might be landed at Goulburn for £5 per ton. The total cost for the clarifying agent would therefore be about £365 per annum. The price quoted in Sydney is £8 per ton, and freight and cartage to the reservoir would probably bring it up to £8 10s. per ton; the cost per annum would therefore be about £620.

This is equivalent to an extra cost of about ½d. to ¾d. per 1,000 gallons.

It is possible that on a large scale a greater proportion of alumino-ferric would be required than that used in the above experiments. The amount would depend upon the time which could be allowed for settlement and could best be determined by an actual trial at the water works. In the author's opinion the use of a clarifying agent, such as alumino-ferric, would greatly improve the water supply and although the laboratory experiments show that the clarified water is not fit for drinking purposes, it is possible that on the large scale with an efficient sand filtration process the water might be rendered suitable for all purposes. The Municipality of Goulburn is strongly recommended to test the effect of alumino-ferric on the large scale with the plant at present at their disposal. If the water is sufficiently improved to be suitable for all purposes, the plant could be increased to deal with the maximum amount of water required; if not, a new source of supply must be sought. In conclusion I desire to thank Professor Schofield for affording me the opportunity of performing these experiments and also for much advice during the work.

CHEMICAL EXAMINATION OF THE OIL FROM THE SEEDS OF *BURSARIA SPINOSA* (BLACKTHORN).

By E. GRIFFITHS, B.Sc., Junior Demonstrator in Chemistry, University of Sydney.

(Communicated by Prof. J. A. SCHOFIELD).

[*Read before the Royal Society of N. S. Wales, December 1, 1909.*]

THE fruit from which the seeds were obtained was collected during March and April along the Nepean at Camden. In order to obtain some idea of the nature and amount of extract yielded to the various solvents, a small quantity (20 grams) of the finely ground air-dried seed was first extracted in the cold, with the following solvents in the order given. The solvent was removed from the extract by evaporation and the residue dried to constant weight in a steam oven.

Petroleum ether (b. p. up to 45° C.) removed	17·21%
Ether	0·3
Alcohol (90%)	9·4

The petroleum ether extract consisted of a yellow transparent oil which did not solidify at ordinary temperature. On passing a stream of the oxides of nitrogen, generated from HNO_3 and starch through a few drops of the oil and allowing to stand over-night a solid elaidin was formed. The oil was completely soluble in ether and hot alcohol and was readily saponified by hot alcoholic potash.

Systematic Examination of the Oil.—In order to obtain sufficient oil to determine its constituents and constants, 730 grams of the finely powdered air-dried seeds were thoroughly exhausted by petroleum ether (b. p. up to 45°C.) in a continuous percolator. The extract was evaporated

in a partial vacuum the last traces of solvent being removed by gently heating the oil in a vacuum desiccator. By this means 135 grams of oily matter were obtained. The oil gave the following constants:—

Saponification equivalent or (Koettstorfer's number)	169·47
Iodine number (Hübl.)	86·4
Acid value	1·26
Specific gravity at 13° C.	0·8867
Refractive index at 22° C.	1·4681

Separation of the Constituents of the Oil.—In order to separate any substances volatile in steam, about 100 cc. of water were added to 100 grams of oil and a current of steam passed through the mixture. The aqueous distillate which amounted to about two litres, was colourless and neutral to litmus, but had a marked odour. It was shaken three times with ether, the ethereal layer was separated, dried over calcium chloride and the ether removed by evaporation. There remained about two drops of a yellow viscid oil with a very marked odour. The quantity was too small to examine further. After the distillation there remained in the flask two liquid layers, (A) an upper oily layer and (B) a lower watery layer. Nothing could be separated from the watery layer (B). The oily layer (A) was separated and saponified by heating with alcoholic potash. The alcohol was removed by evaporation and the pasty residue thoroughly mixed with a quantity of pure sand and dried on the water-bath. The dried mass was then placed in an extraction apparatus and extracted with petroleum ether until all soluble matter was removed. The material was by this means separated into two parts, (C) that insoluble in the petroleum ether, and (D) that soluble in that medium.

Examination of portion (C) insoluble in petroleum ether.—The petroleum ether was removed by heating on a water

bath and the soap dissolved in water and filtered. The filtrate was then acidified with dilute sulphuric acid in order to liberate the fatty acids. The free acids which were liquid were separated from the aqueous solution and the latter shaken with ether. The ether was separated from the aqueous solution, dried, and the solvent removed by evaporation. The residue was added to the free fatty acids and the whole dissolved in ether. The ethereal solution of the free acids was then washed with distilled water until the washings were neutral to litmus. The ethereal solution was then dried over calcium chloride and the ether removed by evaporation. The free fatty acids were fluid at ordinary temperatures and no separation of solid matter took place on allowing the acids to stand for a couple of days.

Separation of the fatty acids.—The free fatty acids were converted into their lead salts by heating at a low temperature on a water-bath with excess of lead carbonate. The lead salts were then mixed with ether in a stoppered flask and the whole allowed to stand with frequent shakings for several days. The greater part of the lead salts dissolved. The solution was decanted and the residue washed with ether. The ethereal solution was then shaken with successive small quantities of dilute hydrochloric acid until all the lead salts were decomposed. The ethereal solution was washed, dried over calcium chloride and the ether removed by evaporation. The residual free fatty acid was light yellow in colour. It formed an elaidin and readily absorbed iodine. A combustion of the oil gave results very near to those required for oleic acid

(1) C 75·46%; H 11·67%
(2) C 75·4%; H 11·87%

but the carbon is too low. On allowing this acid to stand in a stoppered bottle for two days at about 20° C. a very small quantity of solid matter separated. This was removed

by filtration. The clear filtrate was then distilled under reduced pressure. The greater portion of the acid came over at 273°–276° C. (uncorrected) and 65–70 mm. of mercury as an almost colourless liquid. On examination it gave the following results:—

(*a*) Iodine value (Hübl.) ... ... 89·14

(*b*) Refractive index at 19·5° C. ... 1·4622

(*c*) Combustion C 76·3, H 11·87, O 11·73%

Theory demands for oleic acid

C 76·5, H 12·05, O 11·45%

These data point to oleic acid as the main constituent of the free fatty acids.

Examination of the fatty acids whose lead salts were insoluble in ether.—The lead salts were decomposed by warm dilute hydrochloric acid and the free fatty acids well washed to separate any soluble lead compounds. The liberated acids weighed about 4 grams and appeared to still contain a large amount of liquid acid. These acids were therefore again converted into lead salts and treated with ether. The acids obtained by this second separation weighed 2·5 grams and melted at 40° C. The mass was dissolved in a small quantity of alcohol and set aside to crystallise. On standing overnight a small quantity (about 0·16 gram) separated in the form of roundish tufts. It melted at 68–69° C. It was redissolved in petroleum ether and the solution cooled. The acid separated again in feathery crystals. This acid (about 0·1 gram) was freed from solvent and dried. A melting point determination gave 68° C. the melting point of stearic acid. This acid is most probably stearic acid, but lack of material prevented its examination being carried any further.

Isolation of glycerol.—The aqueous acid solution obtained after the liberation of the fatty acids was examined for glycerol. The free sulphuric acid was neutralised with

barium carbonate and the whole mass evaporated to a paste at a low temperature on the water-bath. Alcohol was added to the residue and the evaporation repeated. The pasty residue was then extracted several times with alcohol. The alcohol was removed by evaporation when about 10 cc. of a dark coloured very viscous liquid remained. This viscous liquid had the following properties:—

(*a*) it readily mixed with water,

(*b*) it readily mixed with alcohol,

(*c*) it was insoluble in ether,

(*d*) it gave a translucent mark on paper which was removed by water,

(*e*) on heating with $KHSO_4$ a gas having an irritating effect on the nostrils and eyes was evolved. On passing this gas into ammoniacal silver nitrate and warming the solution, a silver mirror was obtained. This viscous residue, therefore, consists mainly of impure glycerol. Several attempts were made to further purify this glycerol by distilling under reduced pressure, but owing to the bumping and frothing, they were unsuccessful.

Examination of the unsaponifiable material extracted from the soap by petroleum ether.—The residue left on removing the petroleum ether was a yellowish liquid while hot, but on cooling it formed a soft buttery mass in which crystals could be distinguished by means of the microscope. The crystals were of two kinds (*a*) colourless rhombic plates  and (*b*) tufts of needle-like crystals *. In order to make sure that the residue contained no unsaponified oil, the residue was heated on the water-bath with a few cc. of alcoholic potassium hydrate. The alcohol was removed by evaporation and the dry residue again extracted by petroleum ether. The residue was similar to that obtained from the first extraction. It was dissolved in alcohol and allowed to stand several hours when a mass of crystalline

rhombic plates together with a much smaller quantity of the crystalline tufts separated. These tufts were more soluble in absolute alcohol than the rhombic plates so that an approximate separation was made by this means. The crystalline residue was separated by filtration and washed three times with alcohol. The residue was again recrystallised from alcohol. The rhombic plates gave the following reactions:—

(1) On warming with sulphuric acid the crystals gave a reddish colour.

(2) On shaking a chloroformic solution of the crystals with concentrated sulphuric acid the chloroform became violet and the sulphuric gave a yellow colour by transmitted light and a green fluorescence by reflected light.

These reactions together with the crystalline form and method of separation show that the rhombic crystalline body is a phytosterol.

The alcoholic filtrate and washings after the separation of the phytosterol were evaporated on a water-bath. The brownish residue which melted though not sharply at 45° C. had a resinous lustre when dry. At this stage through an accident, the greater portion of the phytosterol and waxy body was lost, but it is proposed to continue the study of these two bodies at some future date if sufficient material can be obtained.

Results.—The results of this investigation may be summarised as follows:—Seeds of *Bursaria spinosa* yield by extraction with petroleum ether about 17% of a yellow transparent oil having the following constants:—

Saponification equivalent	169·47
Iodine value (Hübl.)	86·4
Specific gravity at 13° C.	0·8867
Acid value	1·26
Refractive index at 21° C...	1·4681

The main constituent of the oil is oleic acid, which probably occurs as olein, as glycerol was also separated. The oil contains besides the above small quantities of solid acids one of which melts at 68° C. and is probably stearic. Amongst the unsaponifiable constituents of the oil is a phytosterol and a wax-like substance melting, though not sharply, at 45° C.

ON THE ANATOMY OF *MONOPYLIDIUM PASSERINUM* FUHRMANN.

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(From the Bureau of Microbiology, Sydney, N.S.W.)

[With Plate XVIII.]

[*Read before the Royal Society of N. S. Wales, December 1, 1909.*]

DURING the early part of the present year (1909), I collected a number of small tapeworms from the intestine of the common sparrow, *Passer domesticus*, L., and fixed them in hot corrosive-acetic solution. On examining them, they were seen to possess nearly all the characters which Dr. O. Fuhrmann[1] described as being present in his *Monopylidium passerinum*, a parasite of the sparrow and of *Fringilla ruficeps*. Since the original description is brief and some of the structures are not mentioned, I have thought it advisable to figure and describe the worm more fully, especially as there are several points of difference between the two accounts. These, however, may perhaps be explainable by differences in the state of preservation in each case.

[1] Fuhrmann, Centrb. f. Bact., Orig., I, XLV, 1908, p. 528.

The occurrence of this parasite in New South Wales has already been recorded by me.[1] The length of the cestode is about 30 mm. with a maximal breadth of 0·65 mm. (Fuhrmann, 0·75 mm.)

Scolex.—The scolex is comparatively small and is not well marked off from the rest of strobila. If we exclude the suckers, its breadth is not much more than that of the neck region. If they be included, then the greatest breadth is 0·15 – 0·17 mm. The four suckers are strongly muscular and project slightly. Their openings are antero-laterally. The diameter is about 0·08, the cavity being 0·04 mm. in depth. On the anterior end of the scolex there may be seen a very protractile rostellum. In the example figured (fig. 1), this organ is nearly 0·11 mm. long, its swollen rounded extremity being 0·04 mm. across. The latter part is followed by a neck-like constricted portion (0·02 mm.) which merges into the lower or basal division of the rostellum. This appears as a considerably distended (0·08 mm.) structure containing abundant muscle fibres, transverse and longitudinal, the latter passing backwards through the scolex between the suckers. In the state of rest, the rostellum lies within the rostellar sac surrounded by these protractor and retractor muscles. On the apex there are about twenty small hooks placed in a double series, the two rows not being very readily separable. The hooks are 0·016 mm. and 0·014 mm. long in each row respectively. Each has a long delicate attachment and a short relatively broad free part (fig. 5). Dr. Fuhrmann pointed out that there is a certain similarity in the form and size of the hooks to those of *Taenia parvirostris* as described by Krabbe.[2] They seem to me to be rather more curved than

[1] Johnston, Agric. Gazette, N. S. Wales, xx, 1909, p. 584; Rec. Austr. Mus., vii, No. 4, 1909, p. 344.

[2] Krabbe, Bidrag til Kundskab om Fuglenes Bændelorme, 1869, p. 86, and fig. 267.

those shown in Krabbe's figures, but otherwise the resemblance is close.

Strobila.—The scolex is followed by an unsegmented neck of nearly 0·4 mm. long, the breadth gradually increasing from 0·11 to 0·13 mm. The segments are at first very narrow and though transverse septa are present, the marginal limits are not well marked. Then there follows a comparatively rapid increase in length and a very gradual increase in breadth, the serrated margins now becoming evident. In the greater part of the strobila the proglottids are trapezoid, those with well-developed genitalia being about 0·4 mm., increasing to 0·64 mm. in length with a breadth of about 0·5 mm. in the posterior region. Fully ripe segments were not seen, but some which contained developing oncospheres, were about 0·4 mm. broad by 1·2 mm. long. Fuhrmann mentioned that ripe segments may reach 0·45 mm. in breadth by 1·6 mm. in length. There is thus a considerable lengthening and a slight narrowing as ripening progresses. The overlapping of segments is slight and altogether disappears later. Occasionally the trapezoid form may be replaced by a more rectangular shape even in proglottids with well developed genitalia.

Sex openings:—These alternate irregularly. There may be a slight genital papilla present. The cloaca is situated on the edge near the junction of the anterior fourth, and the posterior three-fourths. It is very small and shallow, being only 0·025 mm. in depth.

Muscles, etc.—The cuticle is fairly thick. Below it is a very well marked subcuticular layer. The muscles are rather poorly developed. The longitudinal bundles are in thin strands arranged in two concentric series, the greater number being situated in the outer one. Transverse fibres are very weak, whilst the dorso-ventral fibres were not recognised.

The cortical portion of the parenchyma is comparatively small, the greater part of a transverse section being occupied by the medulla and the subcuticular layer.

Excretory System.—This system consists, on each side, of a very well marked ventral vessel with a lumen of about 0·011 mm., whose course is roughly parallel to the margin of the segment, and of a very small dorsal vessel with a diameter of only 0·004 mm. The ventral vessel lies almost in the middle of the lateral part of the medulla, but in the region of the genital pore it becomes displaced ventrally by the genital ducts which pass between it and the dorsal vessel. It may be easily traced forwards through the neck to near the level of the middle of the suckers. In younger segments, its course may be bow-like or even sinuous. The dorsal trunk is situated almost directly above the larger vessel and lies near the cortex. It is not displaced by the genital ducts. At the posterior end of each proglottid the ventral stem gives off a wide transverse or commissural vessel which does not pass straight across from side to side but forms a distinct arch with the convexity facing dorsally.

Nerves:—The longitudinal nerves are readily seen in stained preparations. They lie ventro-laterally from the ventral vessel, close to the cortex.

Male genitalia.—There are in each proglottis between 25 and 30 testes, each of about 0·05 mm. in diameter. They all lie behind the ovary and occupy the posterior half of the segment, extending from the female glands to the transverse excretory vessel, and from the ventral vessel of one side to that of the other. In transverse section, they are seen to fill nearly all the medulla, but they approach rather more to the dorsal side of it. The vas deferens passes forwards as a strong tube, lying in the median line close to the dorsal boundary of the medulla. It lies well above the vitelline gland, shell gland and other

female parts. Its course here may be straight or somewhat zigzag. In the region of the receptaculum seminis it becomes very considerably coiled, and on passing further forwards the loops become larger while the walls become strongly muscular. The tube now appears as a large twisted mass stretching from the inner end of the vagina or even further back, to the anterior border of the segment. In section this deeply staining structure is seen to occupy the whole of the mid-region of the medulla in the dorso-ventral plane. In all segments examined the windings were much larger and more extensive in their distribution than is shown in Fuhrmann's figure, this being, no doubt, due to the quantity of contained spermatozoa. The vas deferens ultimately passes postero-laterally to enter the cirrus sac.

The cirrus sac is an elongate spindle-shaped organ, or it may even be roughly tubular. Its length is from 0·17 to 0·20 mm., with a maximum width of 0·04 mm. In segments where the cirrus appears everted, the sac assumes an almost spherical form of 0·05 mm. diameter. The male aperture is situated just in front of the female opening, the cirrus sac passing inwards, forwards and somewhat ventrally and lying at about the same dorso-ventral level as the vagina, both being situated just above the displaced ventral excretory vessel and lateral nerve. Near the middle of the anterior part of the segment, it takes up the vas deferens. The muscular walls of the sac enclose a coiled cirrus which is capable of considerable eversion, in some cases measuring at least 0·126 mm. with a breadth of 0·04 mm. As Fuhrmann has already pointed out, the cirrus is covered with a very delicate bristling.

Female genitalia.—The female complex as a whole, occupies a rounded zone near the centre of the segment. The ovary is distinctly two-winged, each part forming a somewhat rounded mass. The "wings" are connected by

a comparatively long narrow "ovarian bridge," from the middle of which there passes off dorso-posteriorly a fairly wide but very short oviduct to the fertilising duct. The total width of the gland is from 0·18 to 0·22 mm. Each wing or lobe is made up of a number of branches or ovarian tubes, the lumen of each being easily traced.

The vagina opens on the same level as, and just posteriorly to, the cirrus sac. It courses inwards and somewhat ventrally, as a very distinct wide tube with rather strong walls, but after passing between the excretory trunk-vessels, the walls become thinner. When it reaches almost to the middle of the segment, it becomes considerably narrowed, and after extending backwards for a very short distance undergoes enlargement to form the spacious thin-walled receptaculum seminis. This structure varies in shape, being usually roughly spherical, though it may be pyriform or spindle-shaped. Its position is between the ovarian lobes, filling this space, and frequently extending posteriorly above and behind the ovarian "bridge." Here it passes into the narrow fertilising duct, a slightly convoluted tube which, after taking up the short oviduct, enters the shell-gland complex.

The vitelline gland appears as a compact rounded organ placed in the midline just behind the ovary and shell-gland. It is from 0·05 to 0·08 mm. broad and from 0·04 to 0·06 mm. long. The vitelline duct passes forwards from its anterior part as a comparatively long, thick tube, to enter the fertilising duct in the region of the shell-gland. The vitelline gland is situated on the same dorso-ventral plane as the lobes of the ovary, but slightly ventrally to the level of the shell-gland. The latter organ is a fairly conspicuous rounded structure lying between the ovarian bridge and the vitelline gland, and dorso-posteriorly to the inner end of the receptaculum seminis. Its diameter is about 0·036 mm.

The fertilised eggs come to lie in the parenchyma behind the female complex in the region formerly occupied by the testes. There are two shells present, the outer being about 0·05 mm. and the inner 0·04 mm. in diameter. The oncospheres are approximately 0·024 mm. long, the embryonal hooklets being 0·012 mm. in length. The polar thickenings mentioned by Prof. Fuhrmann as being present on the embryonic membrane, were seen quite distinctly as deeply staining elliptical structures.

From the foregoing description, it will be noticed that the main differences from Fuhrmann's account are in regard to the female complex.

The genus *Monopylidium*, Fuhrm., was erected in 1899[1] for the reception of *Davainea ? musculosa*, Fuhrm. In 1908[2] a diagnosis of the genus was given, stating that there is a simple circlet of hooks. In *M. passerinum*, Fuhrm., there is a double row, and since this species has been placed by Fuhrmann in his genus, the generic diagnosis will need to be modified in regard to the rostellar armature. The members of the genus may thus possess a single or a double series of hooks.

EXPLANATION OF PLATE XVIII.

Fig. 1. Scolex with rostellum protracted
„ 2. Segment, showing genitalia, etc. (dorsal view).
„ 3 Female genitalia seen from the dorsal side.
„ 4. Transverse section of midregion of segment.
„ 5. Hook.

Explanation of lettering:—*c.*, cirrus; *c.s.*, cirrus sac; *cu.*, cuticle; *c.p.*, cortical parenchyma; *d.e.v.*, dorsal excretory vessel: *f.d.*, fertilising duct; *g.c.*, genital cloaca; *h.*, hook; *l.m.*, longitudinal muscle; *m.*, medulla; *n.*, longitudinal nerve; *o.d.*, oviduct; *ov*, ovary; *ov. br.*, ovarian bridge; *r*, rostellum; *r.m.*, rostellar muscles; *r.s.*, receptaculum seminis; *s.*, sucker; *s.c.c.*, subcuticular cells; *s.g.*, shell gland; *t.*, testis; *tr. e.v.*, transverse excretory vessel; *v.*, vitelline duct; *va.*, vagina; *v.d.*, vas deferens; *v.e.v.*, ventral excretory vessel; *v.g.*, vitelline gland.

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[1] Fuhrmann, Centrb. Bact. Orig. I, xxvi, 1899, p. 622–7.
[2] Fuhrmann, Zool. Jahrb., Supp. Bd. x, i. 1908, p. 65.

LOPE DE VEGA.[1]

By L. Hargrave.

[*Read before the Royal Society of N. S. Wales, December 1, 1909.*]

The paper that was read here on June 2 has brought to light so many facts and incidents that circumstantially supply missing links in the voyage of the "*Santa Isabel*," that no excuse is needed for again touching on the fate of Lope de Vega.

East of the figure of a kangaroo on Woollahra Point, there is a rounded rock with many carvings. By permission of the owner of the property on which this rock is situated, I cleaned a number of boat-shaped marks and found also the numerals 46 with two letters *R e* a little west of the numerals; much of the rock is still covered by a flower bed. I noticed in Mr. Collingridge's book that the old charts there shown have fish and ships on the parts that represent water, and the land is distinguished by sketches of animals, men, and houses. Armed with this knowledge and a compass, I had another look at the rock and easily recognised a track chart cut in the stone. My reading of it is, that it represents the track of a ship in the Tasman Sea from the point where she made the land to the time she entered Sydney Harbour. It appears that she sailed south more than twenty days, then north closer in shore and then west. This of course meant a lengthened sojourn here, and at once scattered any lingering ideas I may have had that our poor blacks had ever cut a rock in mimicry of a Peruvian miner, or for any other reason.

If we attribute all this stone cutting to the industry and religious zeal of the immediate ancestors of the people

[1] Continued from a paper in this Journal Vol. XLII, pt. 1, p. 39.

found here by Governor Phillip, we have to assume that one of the lowest types of humanity had reached a metal smelting age and then suddenly relapsed into barbarism; or, that our blacks were the invaders and had swept away an effete civilization, both of which suppositions are untenable. New South Wales does not know the historical value of the splendid work of W. D. Campbell, who portrayed so many rock carvings; and it is felt that interest in the old times is still keen enough to drag the truth from the pages of this great stone book.

There are a number of notches in the rocks; they are from 6 to 9 inches long, with a V-shaped cross section, and have been produced by rubbing the blunt end of metal tools so as to bring them again to a sharp point. Scrapings from ten of these grooves were taken to Mr. William M. Hamlet our Government Analyst, who sought for any trace of copper that I thought might possibly still remain in the grooves. Mr. Hamlet found no trace of copper, and pointed out that any trace left by the original worker would be converted into carbonate and chloride (from the sea air) and that these compounds would in turn be washed out by countless rains.

A consideration of the lay of the land at Woollahra Point made it plain that it was very favorable for defence against unknown dangers. The level plateau has had a few inches of soil spread over it since Governor Phillip's time, and has been sodded with couch grass. There is no high land from which the rain could have washed this soil down. This thin covering has been worn off at several places, showing carvings that indicate the probability that much more is hidden. Coming further S.W. we see an irregular hollow that must have been a feature of the Point when our first fleet arrived, and held water as it has been cemented since. Turning west there are more rocks,

suitable for carvings and inscriptions, with only a thin skin of soil and sods.

On the flat rock further west, about 20 feet from the harbour there are two eye-bolts leaded into the stone. *These had rings in them once, because the rock is called the "Ring-bolt Rock."* From the height of the lead and the eyes above the stone they appear to have been there very much more than 100 years. The iron is pitted in a manner that shows it has *never been through a rolling mill.* The bolts are 55 feet apart, and taken with their distance from the water's edge, make the supposition reasonable, that they were so placed to careen a vessel that had its two principal masts 5 estadal apart.[1] An estadal is equal to 11·128 feet. The odd $1\frac{1}{2}$ inches is not an excessive error for the much worn end of a sounding pole or ship's measuring rod made far from any standards of length there might have been in Old Spain.

The figure on Woollahra Point is carved on the rounded surface of a rock, the feet are on the top of the rock pointing northward, the head is to the south and at a lower level than the feet. This shows that the expedition was going north after leaving Sydney.

The numerous instances of two-legged one-eared kangaroos show the Archaic Peruvian drawing. The kangaroo at Woollahra Point was also done by one of the miners, but came particularly under the notice of the man or woman (Mariana de Castro) who held the position at Woollahra Point during the absence of the leader while prospecting for gold. This woman knew how things looked that *projected from the other side of things drawn*, and ordered the left ear and paw to be cut. A Peruvian Spaniard would also know, but would not bother to order the additions

[1] **Mr. James H. Watson, (see second footnote on page 417) is unaware that a ship, when careened, is always afloat and moored head and stern.**

to be made: he would say:—"That is good enough." The ear and paw are coeval with the rest of the kangaroo; there is not the slightest difference in the workmanship. They were cut by the same man with the same tools.

The well known figure on Woollahra Point is Mariana de Castro. You say:—"But surely that is a man." For these reasons it is a woman:—

1. She was of a brave and daring character to go on such an expedition.
2. Lope de Vega would not have taken her with him if she had not been so.
3. The absence of flowing robes, even if they were in common use in Peru in 1595, is a style quite natural for a travelling woman to adopt.
4. The short and broad proportions of the figure (5 feet without her sabots) are feminine.
5. The outline of the hair is more than masculine.
6. The coquetry of the ornament in the middle of her forehead, perhaps a great emerald that once graced an Inca's crown, is truly womanish, as well as the large ruff.
7. The simulation of the male is exactly what we should expect in a woman who knew that any moment she might have to fight for her life with naked savages.
8. From the savage's point of view, the masquerade meant one more Peruvian Spaniard to be dealt with; or, if it was omitted, a prize for victory.

Then we have the camp marks, they have a fish-like tail and much resemble the dugong or manatee of Central America. The manatee, by the way, is an object of reverence in parts of South America as the "Spirit of the Water." These possibly are also "Sanctuary" places where the

leader could rest in peace, guarded, by some superstitious dread, from the attacks of his followers. We know about the pentalpha and magic circle of the old necromancers; and the, to us, idiotic folly of a raging foe not daring to slay his deadly enemy when caught with his hand on a church knocker or seated on a stone sanctuary chair.

There are several hundred foot marks in the vicinity of numerous camp marks. These tell the direction and distance of other camp marks. For instance, there are five well-cut foot marks on Woollahra Point. They are in a line S.E. by S., this bearing lands you on the camp mark between Nelson's Bay and Bondi. Following the foot steps N.W. by N. about 30 paces puts you on the Woollahra Point camp mark. The four intervals between these five foot steps average 3 ft. 3 ins. The intervals being of quite abnormal length indicated that they are in no sense a measure, and that it is the five foot steps that record the distance. The vara =2·782 feet was the standard pace, and the five foot steps mean that the camp mark to which they refer was 5,000 vara distant =2·6345 miles. A re-measurement of the distance shows it to be 2 miles 48 chains = 2·6 miles.

Gold was sought. The washing places in the creeks have of course all disappeared, but there is one abandoned claim of many that systematic search would disclose. At Dee Why the spur north of the lagoon is crowned with boulders, the eastern one is a mere shell, the next one to it has on its western face, sheltered from the weather, six deep vertical parallel grooves. The piece of stone between the two northern grooves has been broken out for a sample. The antiquity of the work is beyond dispute. Modern miners do not prospect boulders on the top of eminences.

The locality itself speaks. Deewhy. Mr. Surveyor Meehan in his field book (Cat. No. 86) speaks of "Dy" Beach, the

notes at folio 9 commencing "Wednesday, 27th September, 1815. Dy Beach, marked a Honey Suckle Tree near the Beach. . . ."[1] How could such a name originate if it was not cut, hard by, in the rock? How many men could cut D V in the rock without breaking off the internal point of the V which 200 years of weathering would read D Y? and D V is De Vega.

Within the lighthouse enclosure at South Head, at the S.E. corner there are a number of rocks with hundreds of notches where metal tools have been sharpened. At first we naturally say that the convicts who built the old Macquarie Tower made them when sharpening their picks; on second thoughts we reason that this could not be so *because* the early English settlers were well acquainted with grindstones as we know them. This extensive sharpening of tools indicates that elaborate carvings exist or existed in the vicinity. The Rev. Mr. Styles told me of the figure of a man with cocked hat and drawn sword, thus described to him by one of the men who covered it up with concrete when doing some modern work near there.

There is an immense number of carvings extending at least from Gosford to Botany Bay and back to Kuring-gai Chase, and all that I have inspected show unmistakable indications of metal tool work which cannot be reconciled in any way with the opinion of the President of the Australian Historical Society for this year, who says it is convict work.[2]

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[1] This rock is now covered by a sand dune about 15 feet high.

[2] The following letter which appeared in the *Sydney Morning Herald* of the 14th August, 1909, is here referred to.—(Editors):—"I have carefully read the construction that Mr. Lawrence Hargrave has placed on the carvings on the rocks at Woollahra Point, and also Mr. Huntington's letter (*Herald* of 5th August) in reply. I have waited hoping some other writer, better able than myself, perhaps, to form an opinion, would follow up the subject, but as no one has done so, might I ask you to give room to the conclusion I have come to after inspecting the carvings, ringbolts, and the site.

"I differ from Mr. Hargrave, and think the work is of much more recent date. First, I would like to say that I think the site is about one

The drawings of people are, in most cases, Australian natives who came to visit the camps in a friendly or warlike manner. The arms and implements are what the Australian native visitors carried. The animals, birds and fish are the game that stocked the larder.

An incident is depicted where a native was shot in the heart with an arrow. No Australian natives are archers, Peruvians are or were. This figure is very instructive. The size, 15 feet long, shows the general peacefulness of the intercourse with the natives, and perhaps the only instance of bloodshed. It shows that the hunter of 1600 could exaggerate the size of his game quite as well as the hunters and fishermen of 1900. It shows that the native was slain by a bowman, and not by

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of the most unlikely in the harbour to have been selected on which to careen a ship, as a vessel hauled to the ringbolts would have been on the rocks, and as this point is exposed to the full effects of the north-easterly winds, the destruction of the vessel would be the consequence.

"Previous to 1819 this locality was known as Eliza Point, and on it Captain John Piper had built a handsome residence, which he named Henrietta Villa. Being of a very hospitable nature, this gentleman was given to holding fetes on this property. The first was when the foundation-stone was laid; another was in September, 1817, when 120 guests were present, most of whom were conveyed by water, by a brig called "Alert." Again, we are told a "fete champetre" was held on this point, on which day (December 2, 1819) the name was changed to Elizabeth Henrietta Point. At this were present the Lieutenant-Governor (Lieutenant-Colonel Erskine), Captain Freycinet, of the French man-of-war "Uranie," Mr. Commissioner Bigge, and his secretary, Mr. Hobbes Scott, as well as all the legal, naval, and military officers.

"My reason for stating these particulars is to show that Captain Piper having built a large house in about 1815, the workmen were convicts; the materials would be brought by water as the easiest mode of transit. At the functions the guests were conveyed by water. Everything, therefore, points to the convicts having cut "the carvings" on the rocks. They are decidedly not aboriginal, and, in my opinion, were not done by Peruvian slaves. The figure of the man is the rough outline of a convict triced up to the triangles to be flogged; the extended arms and legs, the trousers bagged at the knees, the heavy-looking feet, all point to this. The ringbolts all tend to the belief that they were used in the days when this point was occupied by its first resident, and his large retinue of (convict) servants. The other carvings can be explained in the same way, and I think, if we look at the subject in a less sentimental or romantic manner, these suggestions of mine may lead to the true interpretation."

(Signed) JAMES H. WATSON,

President, Australian Historical Society."

a man carrying sword or musket. I have a quantity of sketches of other carvings that are not described by W. D. Campbell, which I will not stuff our Journal with. A traveller records on the spot, as permanently as circumstances permit, objects of novelty or interest to him; he also records them in his journal. The journal is often called a lie, lost or long forgotten; but rock markings are as near the truth as poor human nature is capable of approaching.

In 1853 Colonel Barney when at Gladstone, Queensland, found in the sand at South Trees Point, a brass pivot gun about 5 feet long and $1\frac{1}{2}$ inch bore. It was inscribed *Santa Barbara 1596.* Further on at Facing Island on the ocean side, well up in the bush, with the sand and vegetation as a rampart against the sea, lay the remains of a Spanish ship; oak trees had grown up through her timbers. Again, on a projecting detached rock at Auckland Point was carved the face of a man; a date was inscribed thereon which was either 1600 or 1800, probably the former. At South Trees Point, at some remote period an extensive clearing had been made, as the vegetation was stunted and did not reafforest quickly. Two wells had been sunk, which were slabbed with sawn timber. There were traces of a building in which teak had been used, and a stone fence. A large block of stone was noted as having been part of a forge. The conclusions then reached were, that a Spanish ship had been wrecked there, an attempt to form a settlement had been made, and the people were wiped out by the blacks.

Regarding these relics, the inscription on the $1\frac{1}{2}$ inch pivot gun, "*Santa Barbara 1596*," cannot be associated with Lope de Vega's ship that sailed from Callao in 1595, unless we assume the inscription date is 1586 instead of 1596. In favour of this assumption the 6 or 8 in the date

inscribed on the face of a man at Auckland Point shows a similarity between weather-worn sixes and eights, and therefore between nines and eights. Also, the 46 that I found at Woollahra Point might readily be interpreted as 48, except for the deeper indentation at the tail of the 6. Therefore questionable figures in stone must give place to the definite statement of 1596 in brass. Then we have the 1600 date that throws any connection with De Quiros and Torres completely out of court, *because* De Quiros and Torres arrived at the Great Bay of Santo on May 1, 1606; and Torres alone at Orangerie Bay on August 10, 1606.

Mr. Collingridge informs us that after the death of Mendana at Santa Cruz in 1595 the remnant of his disastrous expedition having repaired to the Philippine Islands, returned to New Spain in the year 1596. Here, without doubt, they poured into willing ears the story of the bold course adopted by Lope de Vega. The immediate effect then, as it would be now, was like a spark to gunpowder. The "Santa Barbara" as we will call the tall caravel selected, was rushed with volunteers, and made all speed to the latitude and longitude where De Vega's ship was last seen. They bore with them the all-but-certain knowledge that if they hauled their wind in that spot they would strike the Great South Land and get a share of the wealth in which Lope de Vega was wallowing. The rest seems plain. Lope de Vega had found the goldless nature of the coast, and passed north, either before the "Santa Barbara" was piled up; or, he was too far to the east, say near Mast Head Island, to effect a rescue.

Mr. Collingridge says, Santa Barbara was and is still the patron saint of artillerymen, and it is easy to conceive how her name would be associated with a piece of artillery or a ship carrying artillery. A further consideration of this point indicates that the "*Santa Isabel*," (De Vega's ship)

rescued the crew of the "*Santa Barbara*" in the year 1600.

First, the "*Santa Barbara's*" crew were masters of the Gladstone blacks, otherwise no extensive clearing of the timber could have been made.

Secondly, the amount of rock cutting near Sydney shows that three years might be occupied here in prospecting and exploration, even if Moreton Bay and Hervey Bay were not inspected.

Thirdly, an exploring ship going north with bold land to the west and ample water under her keel would not be as far east as Mast Head Island, she would hug the land and could not miss the castaways.

There is still another view of the itinerary. It is, that the "*Santa Barbara*" made the land off Port Macquarie and joined the "*Santa Isabel*" at Sydney. Both ships then sailed north in company till the "*Santa Barbara*" was wrecked. The relics at Port Gladstone being the work of both ships' companies, both crews continuing the voyage in the "*Santa Isabel*." In support of this:—

1. A direct course by the "*Santa Barbara*" from where Lope de Vega was last seen to Port Gladstone involves the safe passage of many coral dangers at the southern end of the Great Barrier Reef.

2. There are *two* ships' hulls cut in the rock at Meriverie.

3. There are or were "*ships* in full sail on tables of rock near the entrance of Curl Curl overlooking the ocean at Manly Beach." This is reported from Maryborough but not verified yet.

Dunk Island, near Cardwell, is reported as having in a cave, coloured rock drawings of live things. These may show the life-like touch of the artist who wrought in Sydney sandstone.

When passing the Endeavour River in 1867, Karl Thorngren, a reliable witness, told us there were careening ringbolts on the bank of that river. It is certain Capt. Cook did not place them there as the "*Endeavour*" *was put on the mud without delay because she was sinking.*[1] Mr. H. Graham Shaw, Acting Harbour Master at Cooktown, has made enquiry for me from old residents who have no recollection of ever seeing any ringbolts. Mr. Shaw thinks it highly probable that the ringbolts have been covered over when building railway and wharfage on the extreme bank of the river. The weight this statement carries does not depend on the reliability of Thorngren, which without doubt was beyond question, but on my recognition of the Woollahra Point ringbolts being for careening purposes recalling Thorngren's statement accurately. The word *careening* is an unusual word, and therefore I should confidently rely on finding the relics near where Mr. Shaw thinks they would be situated.

June 4, 1909, Mr. J. S. Bruce of Murray Island, writes:—

"The small cannon was found on Ashmore Reef, at the north end of it, when brought here it was very much encrusted, after getting it cleaned I saw no particular marks on it, but no doubt the Brisbane Museum authorities could give you particulars as to its antiquity. . . . The copper that Dr. Lawes spoke to you about was found on two patches of reef close to the island of Makuiag (pronounced Mar-be-ack, Jervis Island) which lies to the west of Murray. There were no remains of a wreck near the copper find; it was surmised that the ship had grounded on the reef patches and the copper was thrown overboard to lighten her and float her off the reef, as the ingots were found in heaps as if thrown overboard; they were very much incrusted with coral and had to be broken out by crowbars.

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[1] The "Endeavour" entered Charco Harbour (Endeavour River), 17th June, 1770, and was put on the mud on the 22nd. On 6th July she warped alongside the bank and got a stage made from the ship to the shore (Lieut. Hicks' *Journal* in Hist. Rec. i (1) pp. 184, 186). In other words, she remained at that spot for 12 days. Hooker's *Banks' Journal*, p. 279, speaks of the stage being erected on the 18th June.—(Editors).

"I never heard the name Devil Devil or Devega used in connection with dance masks here, and can find no trace of Spanish in either their songs or dances. A native in speaking in praise of his mask or dance would use the word *debele* or *debe-debe*, *i.e.*, good; these words would sound to one not acquainted with the language very much like *devil.*

"The fish-traps (at Murray and Darnley Islands) according to legendary lore, were built by two beings with supernatural powers named Kos and Abob, they were gifted with the power of being able to change their form into either fish or birds as required. After they finished the traps at Murray they went to Darnley, built traps there, and so on to different islands until they reached New Guinea eventually. They also taught new languages to the people they went amongst, and took a new name to themselves at each place visited by them; so that though known as Kos and Abob at Murray, they were known only by their adopted name at other islands. No man on Murray Island is supposed to be able to make these traps; the work is considered to be above their powers, they can only repair them. The dykes are only stones laid on top of the coral, but they enclose large areas."

Mr. Bruce's letter makes it plain that the Murray Island immigrants did not come over the eastern reef, but followed the Cape York Peninsula, east or west past Mount Adolphus, east of Moa (Banks Island), and so on to Mar-be-ack (Jervis Island) between Jervis and Orman Reefs.

The season of the year that this happened is shown to be near Christmas, the ship went ashore with S.E. weather. No long stay was made as there are no indications of it as yet. She was neaped once or twice and came off with the north-westerly monsoon flying light and leaky. Went to leeward past the Sisters and brought up on a patch within sight of Murray Island and out of sight of Mount Adolphus. Her final resting place was on a patch of coral or sand, *because* the bananas and cocoa-nuts were salved: it was more to the eastward than Half-way Island, or *Torres*

would have seen the wreck, Torres' ships laid high enough to reach Possession Island.

Hibernia Passage seems a likely place, if there are any sand banks, sand would gather round the wreck and all timber would disappear or be covered with sand. The copper ingots were ancient copper, *being embedded in coral.* They were not Queensland copper or they would have been salved a few months after being jettisoned, and not likely to be thrown overboard as they would form stiffening for a wool ship and been hard to get at. No modern ship *with a chart on board* could get so far north of Prince of Wales channel when passing Torres Straits. The copper being in ingots shows the tools were not brought ready made from Peru, but were beaten out, forged and tempered as required.

If a Peruvian vocabulary exists, a man with Mr. Bruce's unique knowledge of Murray Island would trace any similarity if it was there. I have been unable to obtain any vocabulary of the Cholos or Inca language which is still spoken, to compare with the vocabularies in "The Voyage of the Fly;" later ones would be inferior for the purpose. The legendary lore about Kos and Abob fits most remarkably with matter contained in my former paper (June 2, 1909). The derivation of "Kos" is probably

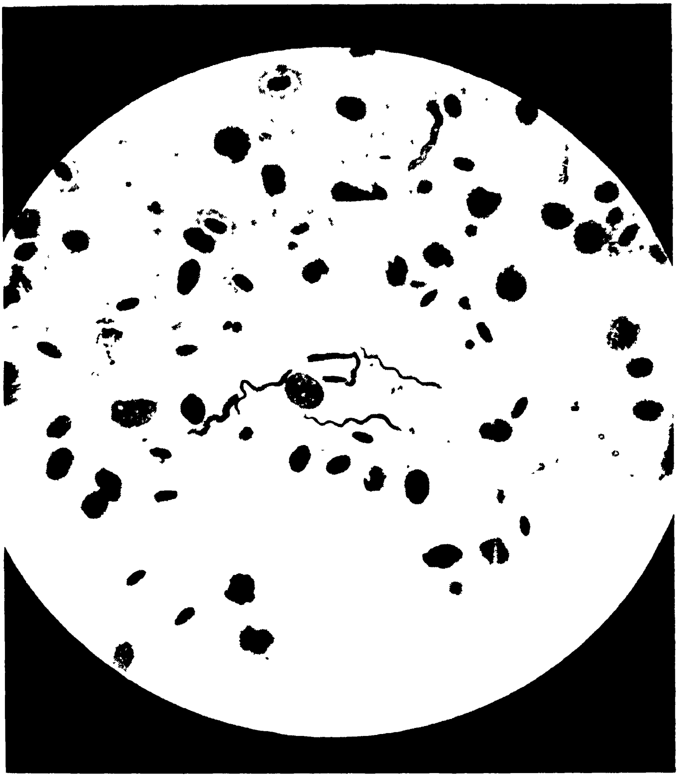
C O S
C A S
C A S T R O.

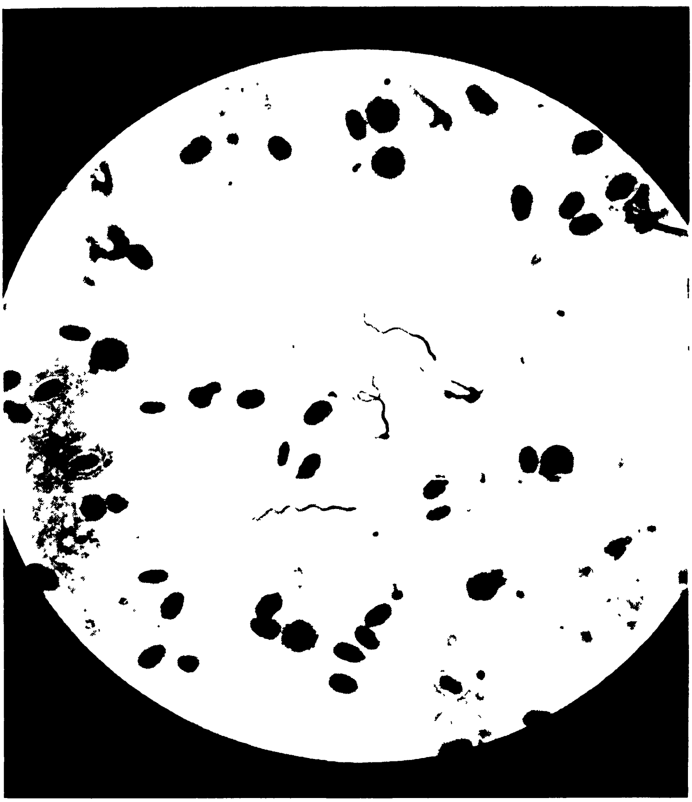
The remora or sucking-fish is used in Torres Straits for catching turtle, in exactly the same manner that the Caribs use it.

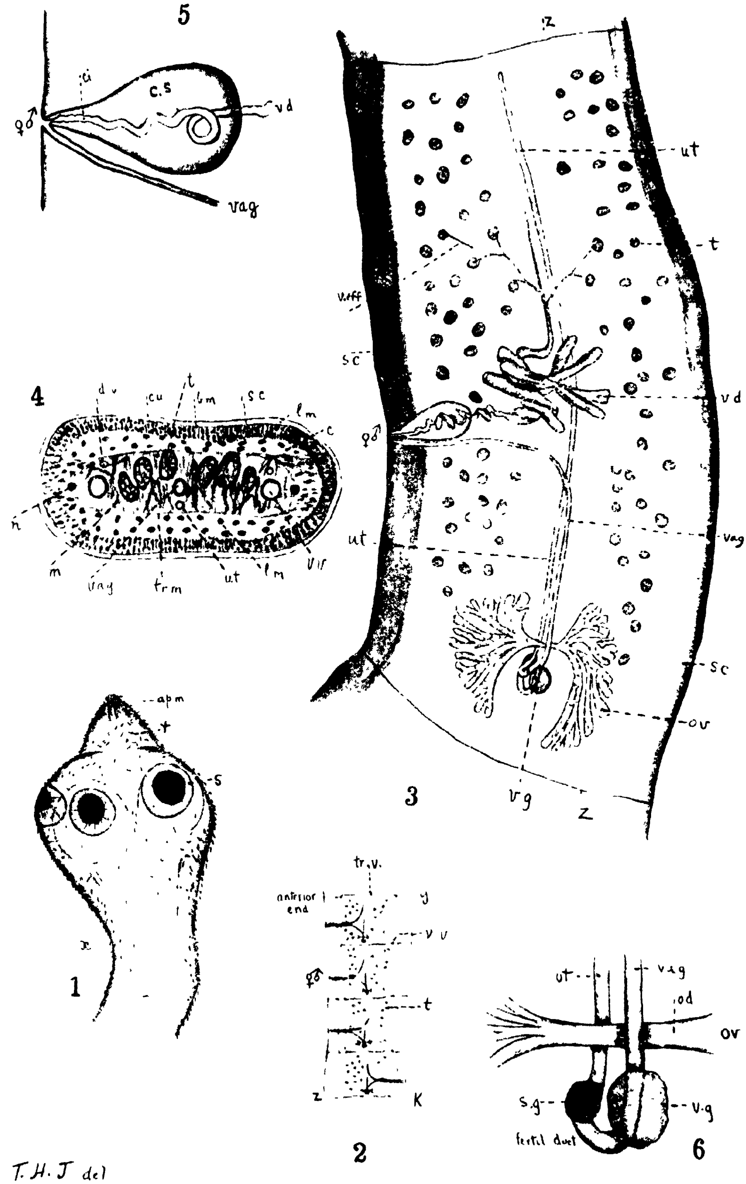
The everyday experience of our law courts tells us how a truth is evolved from most conflicting evidence. The various witnesses, when they have put together in their minds the shreds of knowledge received through their eyes, can only state on oath the view from their mind's eye.

Several of these mind's-eye views when placed before a jury, enable them to form another mind picture that does not coincide with any witness' view, but is what we regard as the truth. Again, we know something of the ways of the American Indians, the Australian black-trackers, and of hunting dogs. They all err repeatedly, but if there is any trail at all, the quarry is generally accounted for. In the case of Lope de Vega; discrepancies, side tracks, flat contradictions and apparently inexplicable facts will all merge themselves into another page of Australian history.

It is self-evident that shadowy and more or less erroneous clues *had to be published* before any generous assistance at all could be obtained. And, as light is thrown on untenable suppositions, the truth is rendered brighter by seeing the inaccuracy from which it grew.



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Site of first bridge over Fish River. Original Bathurst Road. Looking up stream.

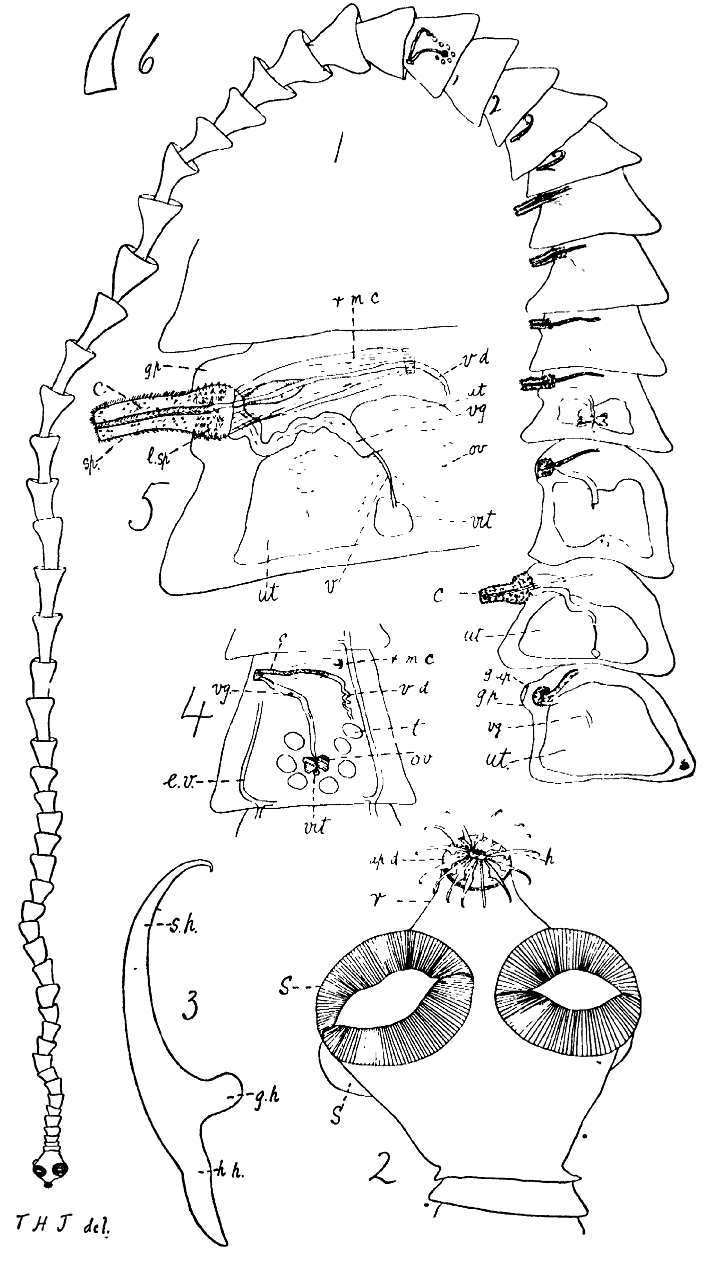
R. H. Cambage, Photo.

FISH RIVER—Showing hills on right bank. Site of first recorded gold discovery in Australia, 15th February, 1823.

R. H. Cambage, Photo.

FISH RIVER—Showing hills on left bank. Locality of first recorded gold discovery in Australia, 15th February, 1823.

R. H. Cambage, Photo.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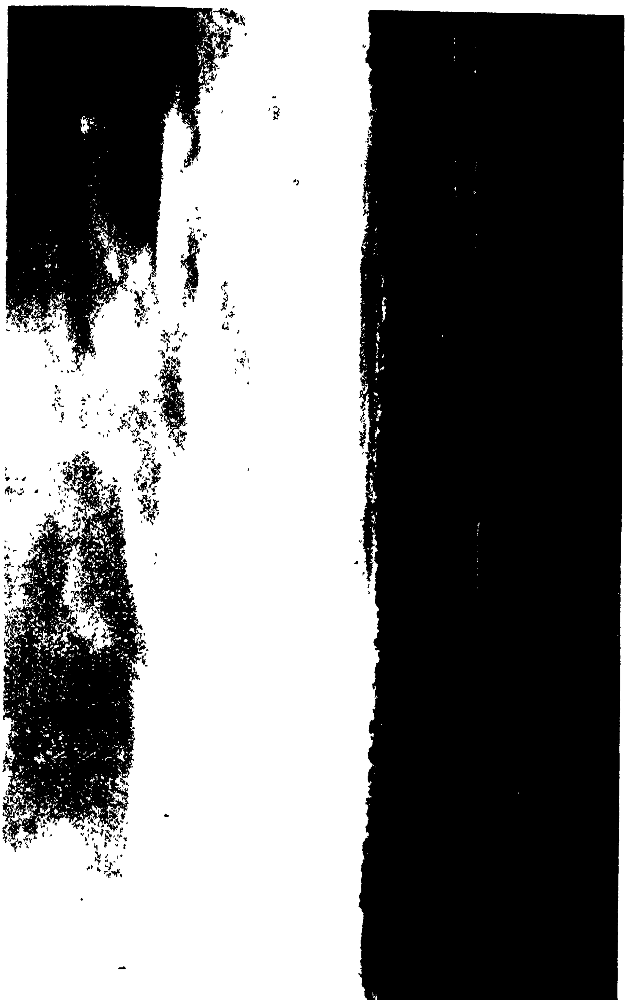


Bowning Hill a residual of the Mount Ainslie Peneplain with the Monaro Peneplain in the foreground.

A. J. Shearsby, Photo.

Gorge of the Murrumbidgee River at Barren Jack.

A. J. Shearsby. Photo.

Monaro Peneplain near Yass

A. J. Shearsby Photo.

Murrumbidgee River near Bredbo at the southern end of the Colinton Gorge.

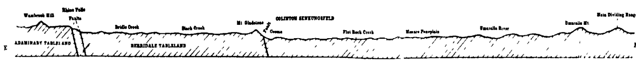
C. A. Sussmilch. Photo.

Valley of the Murrumbidgee River at Taema.

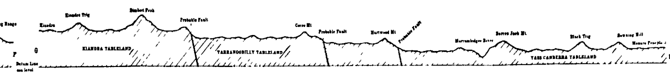
C. A. Sussmilch. Photo

The Colinton Senkungsfeld. Monaro Peneplain in the foreground with the Murrumbidgee Fault-Scarp in the distance.

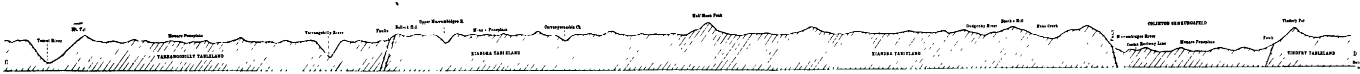
C. A. Süssmilch. Photo.



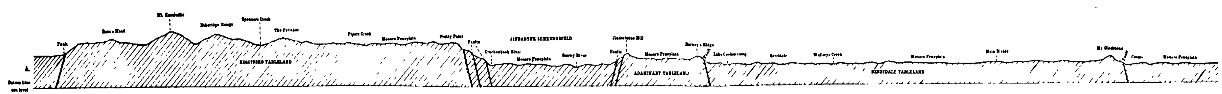
Section from Adaminaby Tableland to Umaralla Mountain



Section (probable) from Kiandra to Bowning



Section from Tumut River to Tindery Pic



Section from Kosciusko Tableland to Cooma

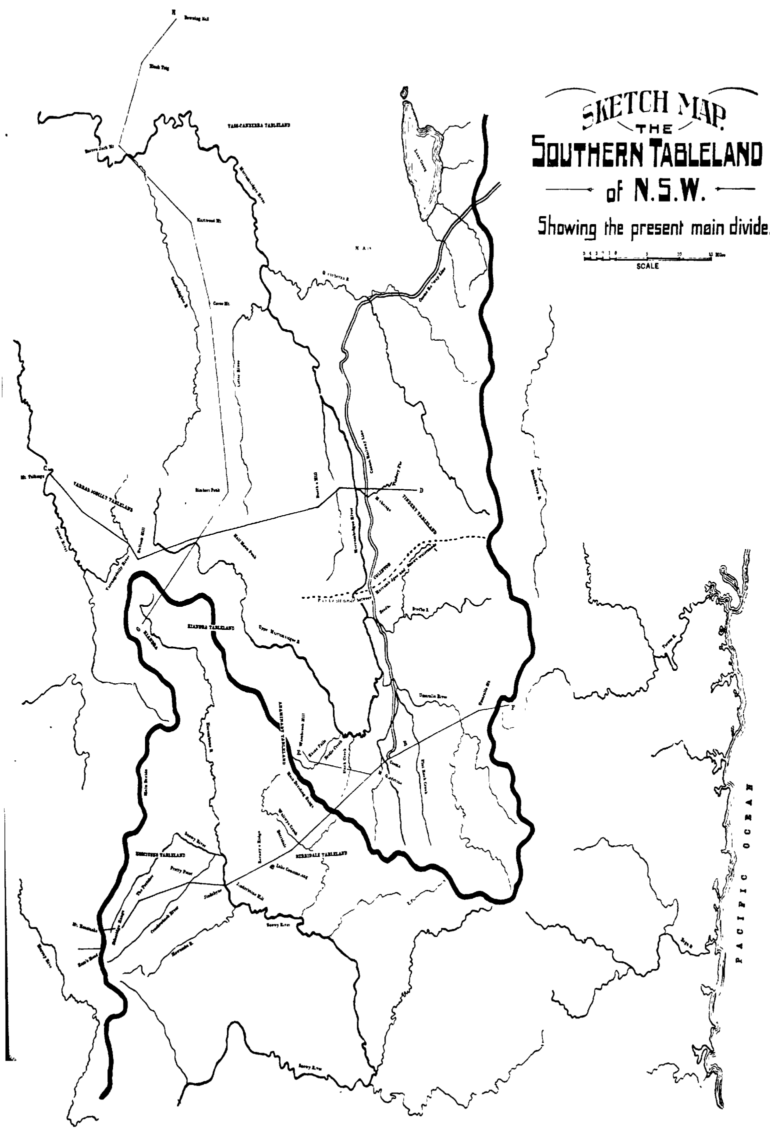
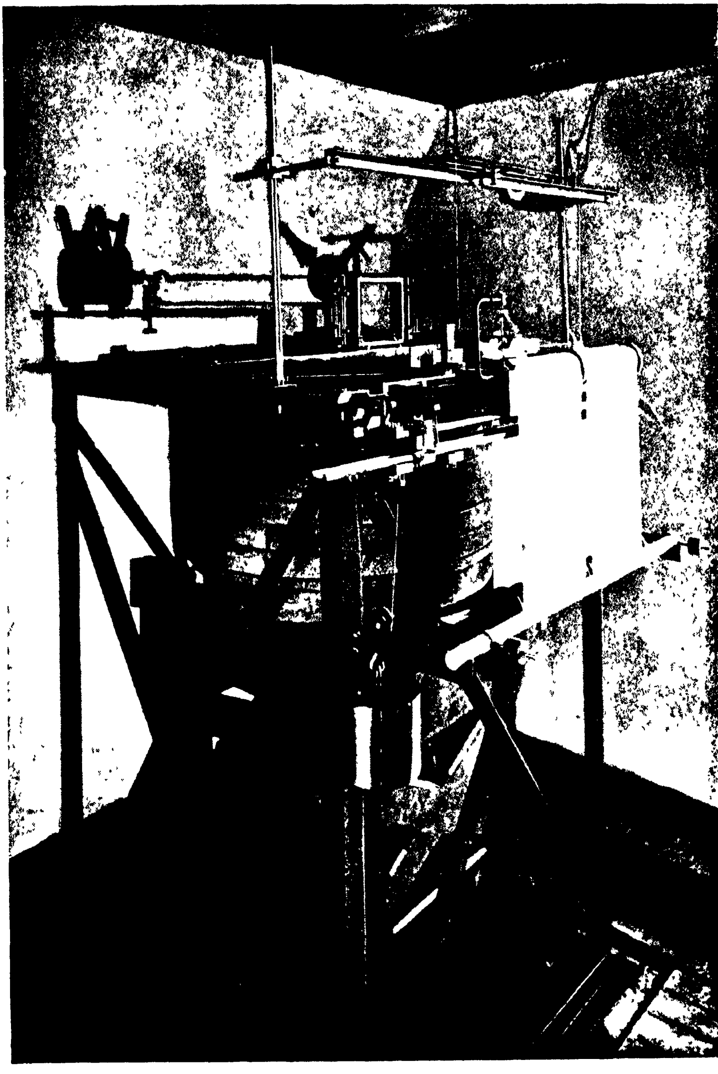
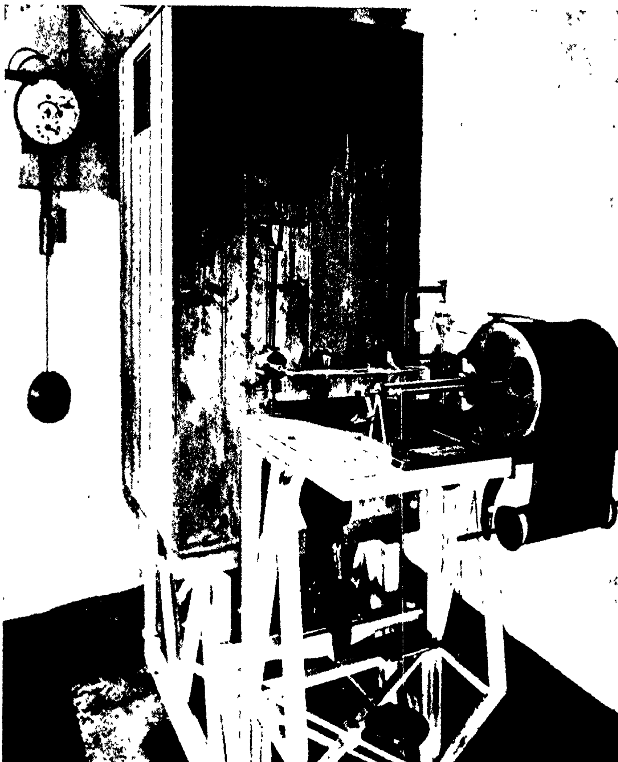

SKETCH MAP
THE
SOUTHERN TABLELAND
of N.S.W.
Showing the present main divide.
SCALE
PACIFIC OCEAN

Plate XIV.

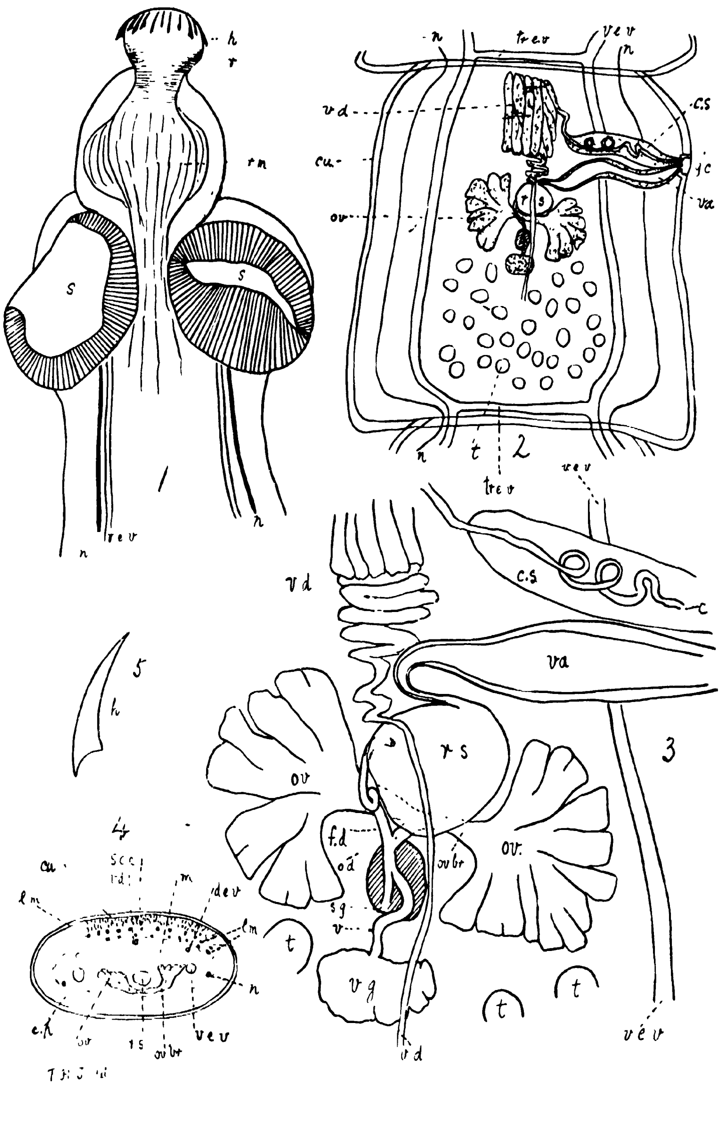


Astatic Pendulum Seismometer (N.S. and E.W. Horizontal Components).



Vertical Seismometer.

Seismograph-cellar, Riverview College.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ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

ABSTRACT OF PROCEEDINGS, MAY 5, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, May 5th, 1909.

W. M. HAMLET, F.I.C., F.C.S., President, in the Chair.

Thirty-five members were present.

The minutes of the preceding meeting were read and confirmed.

The Annual Report of the Council was then read and adopted.

ANNUAL REPORT OF THE COUNCIL.

The Council submit to the members of the Royal Society of New South Wales their Report for the year ended 30th April, 1909.

The number of members on the roll 30th April, 1908, was 340, 10 new members have been elected during the past year. We have, however, lost by death 3 ordinary members 14 by resignation, and 8 names were removed from the roll for non-payment of subscription. There is thus left a total of 325 on the 30th April, 1909, and 16 Honorary Members. The losses by death were:—

Ordinary Members:

MUNRO, Dr. W. J., elected 1887.

RENWICK, Sir ARTHUR, elected 1870.

WILSHIRE, J. T., elected 1878.

During the past year books and periodicals have been purchased at a cost of £79 2s. 5d.; a large number of unbound books and periodicals have been and are being covered in a cheap style of binding which will make them accessible to the members; 645 volumes have been bound at a cost of £49, and 170 volumes are now in the binder's hands.

The number of Institutions on the existing list is 432, and the publications received in exchange for the Society's Journal and Proceedings during the past year were 173 volumes, 2,053 parts, 93 reports, 63 pamphlets, 11 maps, and 4 engravings, total 2,397.

During the past year the Society held 8 meetings at which 18 papers were read; the average attendance of members was 31·3 and of visitors 1·1.

The Engineering Section held 6 meetings at which 2 papers were read and discussed.

A series of Popular Science Lectures, illustrated by lantern slides, was delivered during 1908, at the Society's House at 8 p.m. as follows:—

June 18—"*The Blood in Health and Disease,*" by J. F. FLASHMAN, M.D., Ch.M.

July 17—"*Life under increased Atmospheric Pressure,*" by H. G. CHAPMAN, M.D., B.S.

September 17—"*Carbon Dioxide and some of its Properties,*" by T. STEEL, F.L.S. Illustrated by Experiments.

October 15—"*The Economic Use of Timbers,*" by G. A. JULIUS, B. Sc., M.E.

November 19—"*John Dalton and One Hundred Years of the Atomic Theory,*" by F. B. GUTHRIE, F.I.C.

The following Financial Statement for the year ended 31st March, 1909, was presented by the Hon. Treasurer, received and adopted:—

GENERAL ACCOUNT.

Receipts.	£	s.	d.	£	s.	d
Subscriptions — One Guinea	47	5	0			
„ „ Arrears	3	3	0			
Two Guineas	378	0	0			
„ „ Arrears	79	16	0			
„ „ Advances ...	8	8	0			
				516	12	0
Parliamentary Grant on Subscriptions received— Vote for 1908-1909	400	0	0			
				400	0	0
Rent...				349	15	6
Sundries				54	19	5
Exchange added to Country cheques				0	2	6
Clarke Memorial Fund—Loan				208	8	11
				1529	18	4
Balance on 1st April, 1908				0	16	4
				£1530	14	8

Payments.	£	s.	d.	£	s.	d.
Advertisements	27	6	9			
Assistant Secretary	270	0	0			
Books and Periodicals	79	2	5			
Bookbinding	49	6	6			
Conversazione	78	18	9			
Library	4	5	0			
Electric Light	24	4	2			
Freight, Charges, Packing, &c....	29	12	7			
Furniture and Effects	4	8	0			
Gas	5	4	5			
Caretaker	83	7	6			
Insurance	15	8	10			
Interest on Mortgage	124	0	0			
Office Boy	22	1	0			
Petty Cash Expenses	9	4	0			
Postage and Duty Stamps	26	16	0			
Printing	30	10	0			
Printing and Publishing Journal	268	11	3			
Printing Extra Copies of Papers	14	13	6			
Rates	49	17	8			
Repairs	9	15	0			
Rent of Room, 18 Elizabeth-st., for Storage ...	2	8	0			
Stationery	14	19	0			
Sundries	49	7	1			
Shelving for Books	1	15	6			
Carried forward ...				1295	2	11

Payments—*continued.*	£ s. d.	£ s. d.
Brought forward		1295 2 11
Clarke Memorial Fund—Repaid Loan General Account	208 8 11	
Ditto, ditto, Interest	1 10 8	
		209 19 7
Bank Charges		0 14 6
Balance on 31st March, 1909, viz.:—		
Cash in Union Bank...		24 17 8
		£1530 14 8

BUILDING AND INVESTMENT FUND.

Dr.	£ s. d.	£ s. d.
Loan on Mortgage at 4%		3100 0 0
Clarke Memorial Fund—Loan		228 5 9
		£3328 5 9

Cr.	£ s. d.	£ s. d.
Deposit in Government Savings Bank, March 31st, 1909		1 8 2
Balance of Account, March 31st, 1909...		3326 17 7
		£3328 5 9

CLARKE MEMORIAL FUND.

Dr.	£ s. d.
Amount of Fund, 31st March, 1908	484 8 4
Interest to 31st March, 1909	8 8 7
General Account Repaid on a/c Loan	208 8 11
General Account, Balance...	2 3 6
	£703 9 4

Cr.	£ s. d.
Expenses *re* Lectures, Session 1908	15 7 9
Deposit in Savings Bank of New South Wales, March 31, 1909	241 10 0
Deposit in Government Savings Bank, March 31, 1909 ...	9 16 11
Loan to General Account	208 8 11
Loan to Building and Investment Fund	228 5 9
	£703 9 4

Audited and found correct, as contained in the Books of Accounts

W. PERCIVAL MINELL, F.C.P.A., *Auditor.*

D. CARMENT, F.I.A., F.F.A. *Honorary Treasurer.*
W. H. WEBB. *Assistant Secretary.*

Sydney, 4th May, 1909.

The certificates of five candidates were read for the first time.

There being no other nominations, the following gentlemen were declared duly elected Officers and Members of Council for the current year, viz.:—

President:

H. D. WALSH, B.A.I., M. Inst. C.E.

Vice-Presidents:

F. H. QUAIFE, M.A., M.D.,	WALTER SPENCER, M.D.
HENRY DEANE. M.A., M. Inst. C.E.	W. M. HAMLET, F.I.C., F.C.S.

Hon. Treasurer:

D. CARMENT, F.I.A., F.F.A.

Hon. Secretaries:

J. H. MAIDEN, F.L.S.	F. B. GUTHRIE, F.I.C., F.C.S.

Members of Council:

JOSEPH BROOKS, F.R.A.S., F.R.G.S.	CHARLES HEDLEY, F.L.S.
R. H. CAMBAGE, F.L.S.	T. H. HOUGHTON, M. Inst. C.E.
Prof. T. W. E. DAVID, B.A., F.R.S.	Prof. POLLOCK, B.E., D.Sc.
A. DUCKWORTH, F.R.E.S.	HENRY G. SMITH, F.C.S.
R. GREIG-SMITH, D.Sc.	W. G. WOOLNOUGH, D.Sc., F.C.S.

The President announced that the Journal and Proceedings, Vol. XLII for 1908, was in the hands of the binder and would be distributed as soon as possible.

175 volumes, 905 parts, 53 reports, 39 pamphlets and 22 maps, total 1,194 (including 73 volumes presented by Mr. JOHN PLUMMER) received as Donations since the previous meeting were laid upon the table and acknowledged.

A letter was received from Lady RENWICK acknowledging with grateful thanks the resolution of sympathy of the Council and members of the Royal Society with her in her late bereavement.

The notice of motion by Mr. MAIDEN in July last was brought forward viz:—"That Rule 29 be altered to read "One professional Auditor" instead of "Two Auditors" as at present. On the motion of Mr. MAIDEN seconded by Professor POLLOCK, this was duly carried.

Mr. W. M. HAMLET, F.I.C., F.C.S., then read his Presidential Address.

A vote of thanks was passed to the retiring President, and Mr. H. DEANE WALSH, B.A.I., M. Inst. C.E., was installed as President for the ensuing year.

Mr. WALSH thanked the members for the honour conferred upon him.

ABSTRACT OF PROCEEDINGS, JUNE 2, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, June 2nd, 1909.

H. D. WALSH, B.A.I., M. Inst. C.E., President, in the Chair.

Twenty-six members were present.

The minutes of the preceding meeting were read and confirmed.

Dr. T. COOKSEY and Mr. D. J.-K. COLLEY were appointed Scrutineers and Mr. H. DEANE deputed to preside at the Ballot Box.

The certificates of five candidates were read for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

CALVERT, THOMAS COPLEY, Manly.

CARNE, JOSEPH EDMUND, Department of Mines.

CHAPMAN, H. G., M.D., University of Sydney.

CLELAND, JOHN BURTON, M.D., Bureau of Microbiology.

FAWSITT, Professor CHARLES EDWARD, D.Sc., University of Sydney.

The President made the following announcements:—

1. That six volumes, 101 parts, 7 reports, and 293 pamphlets, total 407, received as donations since the previous meeting, were laid upon the table and acknowledged.

2. That the first Popular Science Lecture of the Session would be delivered on Tuesday, June 22nd, at the St. James' Hall, Phillip Street, on "Antarctic Notes," by Professor T. W. E. DAVID, F.R.S., etc.

3. A letter had been received from Dr. SPENCER stating that there would be a meeting of the British Science Guild, N.S. Wales Branch, in the Hall on Tuesday, the 15th inst., and inviting members to be present.

4. A letter had also been received from the University of Sydney Medical Society, enclosing circular *re* untimely death of Dr. THOMAS CARLYLE PARKINSON, and the steps taken to perpetuate his memory.

Resolved that information contained in the circular be included in the next abstract.

University of Sydney Medical Society.

May 14th, 1909.

At the Annual Meeting of the Society the following motions were proposed by the President, and unanimously carried:—

1. That it be placed on the records of the University of Sydney Medical Society that the members of the Society deeply and sincerely regret the untimely death of THOMAS CARLYLE PARKINSON, one of the most brilliant graduates of the Medical School and an ex-President of the Society, whilst engaged on research work on Plague Commission of 1908.
2. That a sub-committee be at once formed to take steps to perpetuate his memory by erecting a tablet and establishing an Annual Prize in Pathology at the Medical School.

THOMAS CARLYLE PARKINSON passed straight through the Medical Course at the Sydney University, obtaining the highest honours each year, finally graduating with high distinction, and

was awarded the University Medal. He was two years at the Royal Prince Alfred Hospital, the first year as House Surgeon and Physician, and the second year as Resident Pathologist. Later he was Resident Pathologist at Callan Park Hospital. Obtaining the James King of Irrawang, Scholarship in 1908, he proceeded to London, was appointed on the Indian Plague Commission, and went to live at the isolated laboratory at Elstree, Hertfordshire, where he accidentally infected himself, and died of plague pneumonia on 4th January, 1909, aged 26 years.

Subscriptions to be sent to

ARCHIE ASPINALL, W. S. BROOKS } Hon. Secs.

THE FOLLOWING PAPERS WERE READ:

1. "On a Pitchblende probably occurring in New South Wales," by T. H. LABY, B.A. [Communicated and read by F. B. GUTHRIE, F.I.C., F.C.S.]

2. "The Viscosity of Water," by R. HOSKING, B.A. [Communicated by Prof. POLLOCK.]

Remarks were made by O. VONWILLER, B. Sc.

3. "A contribution to the Experimental Study of the Large Ions in the Air," by S. G. LUSBY, M.A. [Communicated by Prof. POLLOCK.]

4. "The Mobility of the Large Ions in the Air," by Prof. J. A. POLLOCK, B.E., D. Sc.

5. "Lope de Vega," by L. HARGRAVE.

Remarks were made by J. H. MAIDEN, F.L.S.

6. "Note on the Determination of the Free Acid in Superphosphates," by F. B. GUTHRIE, F.I.C., F.C.S., and A. A. RAMSAY.

Remarks were made by Dr. R. GREIG SMITH, Dr. T. COOKSEY, and J. A. SCHOFIELD, A.R.S.M., F.C.S.

EXHIBIT:

Mr. J. H. MAIDEN exhibited:—*a.* A natural graft between the timbers of the Salt-water Swamp Oak (*Casuarina glauca*)

and Spotted Gum (*Eucalyptus maculata*) from the Wallamba River, N.S.W. Found by Messrs. Wright and MacLaren and transmitted by Messrs. Allen Taylor & Co., Sydney. The exhibitor drew attention to his paper "On some Natural Grafts between Indigenous Trees," in the volume for 1904. The "fusion" or interlacing of the tissues of the two timbers is perfect. The exhibit is especially interesting since such grafts between two different genera have rarely ever been recorded. *b.* A specimen of a joint of that form of Prickly Pear *Opuntia ficus-indica* which is known as *amyclea*, in which the fruit is absolutely embedded in the tissue, instead of being sessile on the joint as usual. The fruit has ripened in this situation. This teratological specimen is quite novel to the exhibitor.

ABSTRACT OF PROCEEDINGS, JULY 7, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, July 7th, 1909.

H. D. WALSH, B.A.I., M. Inst. C.E., President, in the Chair.

Twenty two members were present.

The minutes of the preceding meeting were read and confirmed.

Dr. J. B. CLELAND enrolled his name and was introduced.

Dr. W. G. WOOLNOUGH and Mr. R. P. SELLORS were appointed Scrutineers, and Mr. JOSEPH BROOKS deputed to preside at the Ballot Box.

The certificates of three candidates were read for the second time, and of six for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

ANDREWS, E. C., B.A., Department of Mines.

JOHNSTON, THOMAS HARVEY, M.A., B. Sc., Bureau of Microbiology.

YEOMANS, RICHARD JOHN, 14 Castlereagh-street.

The President made the following announcements:—

1. That the second Popular Science Lecture of the Session would be delivered on Thursday, July 15th at 8 p.m., on "Some recent work in connection with Radio-activity" by J. P. V. MADSEN, B.E., D. Sc.

2. That 27 volumes, 213 parts, 15 reports and 12 pamphlets, total 267, received as donations since the last meeting were laid upon the table and acknowledged.

A letter was received from Mrs. J. T. WILSHIRE desiring to convey to the members of Council her sincere thanks for their kind message of sympathy in the sad loss sustained by the death of her husband.

THE FOLLOWING PAPERS WERE READ:

1. "Description of a new Haemoprotozoa from Birds in N. S. Wales." by J. BURTON CLELAND, M.D., Ch. M., and T. HARVEY JOHNSTON, M.A., B. Sc.

2. "On a new Melanin-producing Haematozoon from an Australian Tortoise," by T. HARVEY JOHNSTON, M.A., B.Sc. and J. BURTON CLELAND, M.D., Ch. M.

3. "On a new Reptilian Cestode," by T. HARVEY JOHNSTON, M.A., B. Sc.

Remarks were made by Messrs. C. HEDLEY, J. A. SCHOFIELD, and the President.

4. "On the Discrepancy between the Results Obtained by Experiments in Manuring, etc., in Pots and in the Field," by LIONEL COHEN. (Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

Remarks were made by Mr. C. ROSS. Mr. L. COHEN, replied.

EXHIBITS:

1. Mr. E. ESDAILE exhibited (1) an helio-chronometer with universal adjustments and automatic correction for equation of time; (2) Terrestial globe rotated by clockwork, and showing the time at any part of the earth at a glance.

2. Mr. J. H. MAIDEN exhibited specimens showing remarkable instance of repair in the wood of *Pawlownia imperialis*, over the scar of a branch which had been removed, and a root of the same tree penetrated by the root of *Pinus pinea*, grown at Concord near Sydney.

3. Mr. T. H. JOHNSTON exhibited specimens of (Tape) Worms, etc.

ABSTRACT OF PROCEEDINGS, AUGUST 4, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, August 4th, 1909.

H. DEANE, M.A., M. Inst. C.E., Vice-President, in the Chair.

Twenty-nine members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The following gentlemen enrolled their names and were introduced:—Dr. HENRY G. CHAPMAN, R. J. YEOMANS, and T. HARVEY JOHNSTON, M.A., B.Sc.

Mr. C. A. SÜSSMILCH and Mr. WILLIAM WELCH were appointed Scrutineers and Mr. HENRY G. SMITH deputed to preside at the Ballot Box.

The certificates of six candidates were read for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

CHALMERS, NATHANAEL, M. Inst. C.E., L.S., 12 Hoskins Buildings, Spring-street.

DAVIDSON, GEORGE FREDERICK, 223 Bridge-street, Glebe Point.

FITZGERALD, JOHN DANIEL, 82 Victoria-st., Potts' Point.

LAWRENCE, RICHARD PRIESTLEY, M. Inst. C.E., 12 Hoskins Buildings, Spring-street.

PIGOT, Rev. Father EDWARD F., S.J., B.A., M.B. Univ. Dub., St. Ignatius College, Riverview.

RHODES, THOMAS, Carlingford, and Public Works Department, Sydney.

The Chairman made the following announcements:—

1. That the Popular Science Lecture on "Torres Straits" would be postponed till September 16, and that the one on "Art Forms in Nature" by E. J. GODDARD, B.A., B.Sc., would be delivered on August 19th.

2. That on the motion of Mr. CAMBAGE seconded by Mr. BROOKS the Council had agreed to the re-formation of the Geological Section.

3. That 12 volumes, 165 parts, 12 reports, 11 pamphlets and 4 maps, total 204, received as Donations since the last meeting were laid upon the table and acknowledged.

THE FOLLOWING PAPER WAS READ:

"Botanical, Topographical and Geological Notes on some routes of Allan Cunningham," by J. H. MAIDEN F.L.S., and R. H. CAMBAGE, F.L.S.

Remarks were made by Mr. CLUNIES ROSS, Dr. WOOLNOUGH, Mr. J. H. MAIDEN, Dr. HOUISON, and Mr. CAMBAGE.

EXHIBITS.

1. Mr. J. BROOKS exhibited Standard inch "N.P.L. No. 812" made of Invar—a nickel-steel alloy, by J. H. Agar

Baugh, 92 Hatton Gardens, London E.C., with Dr. Glazebrook's certificate of length.

2. Messrs. BAKER and SMITH of the Technological Museum exhibited a section of the timber of *Callitris intratropica*, recently received from Northern Australia, upon which had crystallised out a quantity of guaiol, the sesquiterpene alcohol which occurs in the timber of all species of Callitris. Guaiol has been obtained in quantity from the timber of the "White Cypress Pine," *Callitris glauca*, and its occurrence in this genus was notified to this Society at the August meeting of last year, and is recorded in the Society's Journal, p. 170.

3. Mr. T. H. JOHNSTON exhibited a number of entozoa, many of which had previously not been recorded as occurring in New South Wales, whilst some had not been known to occur in Australia. The following species were represented:—*Syngamus trachealis*, the "gape-worm" of fowls, (N.S.W.) not previously recorded from this State; *Oxyspirura mansoni*, the "eye-worm" of chickens (N.S.W.), not previously recorded from Australia; *Davianea echinobothrida*, a cestode producing the "nodular disease" in fowl's intestines (Fiji); *Moniezia planissima* and *M. expansa* both from sheep and cattle, (N.S.W.), the former which was now recorded for the first time from Australia, being uncommon, especially in sheep, the latter often occurring in both hosts; *Strongylus filaria*, from the lungs of sheep (N.S.W. and Tasmania); *Hæmonchus contortus*, from sheep (N.S.W.); *Trichocephalus affinis*, from sheep and cattle, (N.S.W.), and from sheep (Tasmania), other species of this genus known to occur in our State being *T. trichiurus* (*T. dispar*) from human beings, *T. crenatus* from the pig, and *T. nodosus* from the mouse, all three however being uncommon; *Œsophagostomum columbianum*, from sheep and cattle (N.S.W.), the larvæ forming nodules in the wall of

the intestine, the adult form being found in its lumen—not previously reported from cattle in our State; *Stephanurus dentatus (Sclerostomum pinguicolum)*, from the renal tract of a pig (N.S.W.); *Ankylostoma (Uncinaria) trigonocephalum*, from a dog (N.S.W.), a parasite producing effects similar to those caused in human beings by its ally, *A. duodenale*, which was unfortunately becoming rather common in Queensland. He also exhibited two ticks belonging to species which were responsible for carrying the organisms of diseases, viz., *Margaropus annulatus*, the "Queensland cattle tick," which transmitted *Babesia* (*Piroplasma*) *bigemina* producing Piroplasmosis (tick-fever) in cattle in Queensland and occasionally in New South Wales and West Australia; and *Argas americana*, the carrier of *Spirochæta anserina (S. gallinarum)*, the organism of fowl tick-fever (Spirochætosis) a disease occurring in this State.

4. Mr. J. H. MAIDEN exhibited a small tree of *Pinus radiata* (*insignis*) from Leura, Blue Mountains, throttled through a neglected string-tie.

5. Dr. SPENCER exhibited a copy of Lilley's predictions of the Great Plague and Great Fire in London. Rare books containing illustrations by Rowlandson. Two pamphlets published during the first French Republic, in which the revolution was attributed to the machinations of Freemasonry.

Abstract of lecture on "Art Forms in Nature," by E. J. GODDARD, B.A., B.Sc., Linnean Macleay Fellow in Zoology, delivered 19th August, 1909. The lecture dealt with the more artistic typical forms of plants and animals, illustrated with a big series of lantern slides copied from Haeckel's beautiful plates. The lower forms of vegetable life were represented by typical microscopic algæ and the various coloured sea-weeds. The microscopic algæ included *Volvox* and other members of the same group, the disc-shaped

Pediastrum etc., varieties of *Desmids* shewing the shapes and structures of these objects, and *Diatoms*, whose siliceous skeletons were shewn in every form and shape, the consistency of which facilitated their preservation in the fossil condition, an example of such being instanced at Cooma. The function of chlorophyll in these microscopic plants as well as in the larger was explained, and by contrasting plants and animals on the presence or absence of this substance the lecturer passed on to a discussion of the more artistic animal forms. Among the unicellular animals —*Protozoa*—were shewn the various types of *Foraminifera* with their calcareous skeletons forming such deposits as Globigerina ooze and chalk, and not occurring at a greater depth than 2,500 fathoms; the varied types of *Radiolaria* with their siliceous skeletons of complex shape and beautiful symmetrical forms occurring at all depths in the ocean; the animalcules causing phosphorescence in the ocean, etc. Proceeding to multicellular forms the lecturer dealt with the various types of spicules composing the skeleton of sponges and some beautiful deep sea sponges with tufts of siliceous glassy spicules for attachment to the bed of the ocean and dealt briefly with the anatomy of these animals. The *Coelenterata* were represented by *Zoophytes*, Blue-bottles, *Medusæ* and beautiful jelly-fishes with their long trailing arms, sea anemones, corals, sea-pens, and comb-jellies, the common points of structure among all these animals being explained by the lecturer. The artistic forms of sea mats and fresh-water *Polyzoa* were shewn as representative of the *Molluscoidea*, and the general structure and appearance of *Rotifers* (wheel animalcules) were pointed out, together with the occurrence of resting buds and the power of withstanding desiccation. Starfishes with their tube feet and hollow arms, brittle starfishes with their small disc and long slender arms, sea urchins, cake urchins, heart urchins,

feather stars, sea lilies (now so poorly represented and confined to the depths of the ocean) with their interesting palæontological history were instanced in contrasting their hard skeletons with that of the other division of the *Echinodermata*—the sea cucumbers with their long oval tentacles and microscopic spicules of beautiful form. *Mollusca* were represented by Nudibranchs devoid of the shell usually found in the group and furnished beautiful marginal branchiæ and brilliant colouration; also the ancient representatives—*Ammonites*—representing our now-a-days unique *Nautilus*. Fishes were represented by box and file fishes with their strong dentition enabling them to crush off pieces of coral in their habitat—coral seas. The lecturer, in conclusion, pointed out the opportunities which lay open to any one with an inquiring mind to spend time profitably and get healthy amusement even in the examination of pond waters, or in a stroll along the sea beach after a storm, remarks well summed up in the sentiment:

> "Tongues in trees,
> Books in the running brooks, sermons in stones,
> And good in everything."

ABSTRACT OF PROCEEDINGS, SEPTEMBER 1, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, September 1st, 1909.

Dr. WALTER SPENCER, Vice-President, in the Chair.

Twenty-five members were present.

The minutes of the preceding meeting were read and confirmed.

Mr. J. A. Schofield and Mr. W. J. Clunies Ross were appointed Scrutineers and Mr. Joseph Brooks deputed to preside at the Ballot Box.

The certificates of three candidates were read for the second time, and of four for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Madsen, John Percival Vissing, D. Sc., B.E., University of Sydney.

Stokes, Edward Sutherland, Metropolitan Board of Water Supply.

Woodhouse, Prof. William John, M.A., University of Sydney.

The Chairman announced:—

1. That a Popular Science Lecture on "Torres Straits," by Charles Hedley, F.L.S., would be delivered in the Society's Hall, on Thursday, September 16th, at 8 o'clock.

2. That 20 volumes, 134 parts, 22 reports, 23 pamphlets and 19 maps, total 218 received as Donations since the last meeting were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "On a new Genus of Bird-Cestodes," by T. H. Johnston, M.A., B. Sc.
2. "A complete Analysis of Sydney Water," by Sidney G. Walton, was communicated and read by W. M. Hamlet, F.I.C., F.C.S.

Remarks were made by Dr. Stokes, Messrs. Loxley Meggitt, F. B. Guthrie, W. M. Hamlet, and A. Duckworth.

3. "A plea for the study of Phenological Phenomena in Australia," by J. H. Maiden, F.L.S.

Remarks were made by Messrs. R. T. Baker, W. J. Clunies Ross, R. H. Cambage, A. Duckworth, F. B. Guthrie, and the author.

Owing to the lateness of the hour the reading of the paper "Notes on Flour-Strength," by F. B. GUTHRIE, F.I.C., F.C.S., and G. W. NORRIS was postponed to the next meeting.

EXHIBITS.

1. Mr. J. A. SCHOFIELD exhibited a new automatic stop-funnel for filling bottles with liquids, the flow automatically ceasing as soon as the bottle is full. The funnel belongs to Mr. SIBLEY (of Mauri Bros. and Thomson).

2. Mr. W. J. CLUNIES ROSS exhibited specimens to illustrate the attempt to grow pearls artificially within the oyster. From Thursday Island.

3. Mr. T. H. JOHNSTON of the Bureau of Microbiology, exhibited slides of the Irish Blight fungus, *Phytophthora infestans* from potatoes from Tasmania and Richmond River, N. S. Wales. He also exibited a series of parasites including *Paramphistomum cervi* in the stomach of an ox (N.S.W.); hydatids, (*Echinococcus polymorphus*) in the rib of an ox (N.S.W.) and in the heart muscles of a pig (N.S.W.); *Notoedres alepis* (*Sarcoptes muris*) on the ears and tail of *Mus decumanus* (N.S.W.), a parasite which Dr. Cleland had found on *Mus alexandrinus* in West Australia—this itch mite or mange mite being allied to *Sarcoptes scabiei* from man, *S. minor* (*S. cati*) of the cat, *S. canis* of the dog, all of which occur, though rarely, in our State; *Laelaps agilis* ? from *Mus rattus*, *M. alexandrinus*, *M. decumanus*; and *Ixodes* sp. from *Mus decumanus*, all these acarids being obtained in Sydney. He also reported the occurrence in West Australia of the following entozoa, *Taenia saginata*, *Ascaris lumbricoides* and *Oxyuris vermicularis*, all of these were previously unrecorded from that State, these records being based on reports collected by Dr. Cleland whilst attached to the Board of Health, Perth, W.A.

Abstract of lecture on "Torres Straits," by C. HEDLEY, F.L.S., delivered 16th September, 1909. The lecturer

remarked that Torres Straits in dividing the largest island from the smallest continent, separated different races of men and diverse fauna and flora. A parallel was drawn between Torres Straits and the Straits of Dover. Both were once dry land and invading forces both of men and animals here found entrance. The incessant warfare that prevailed between the raiding parties of Papuan head hunters and Australian aborigines ended in victory for the defenders whose javelin and spear-thrower out ranged the bamboo bow and arrow of the islanders. The Papuans attained a higher level of culture than the nomad hunters of the mainland, they were expert mechanics, successful agriculturalists, keen traders and sailors. Geologically the area has a threefold division. A series of high granite islands extend north of Cape York and are the drowned mountain peaks of a range that once formed a broad isthmus between New Guinea and Australia. East of the continental zone is the coral area of numerous islands of the cay type. This is really a continuation of the Great Barrier Reef. East again of this is the volcanic zone embracing a series of recent but denuded ash cones and lava flows. The scenery and people were pourtrayed in coloured lantern slides.

ABSTRACT OF PROCEEDINGS, OCTOBER 6, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, October 6th, 1909.

Dr. WALTER SPENCER, Vice-President, in the Chair.

Twenty-three members were present.

The minutes of the preceding meeting were read and confirmed.

Dr. STOKES and Dr. ANDERSON were appointed Scrutineers and Mr. D. CARMENT deputed to preside at the Ballot Box.

The certificates of four candidates were read for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

BENSON, WILLIAM NOEL, Junior Demonstrator in Geology, University, Sydney.

COTTON, LEO ARTHUR, Linnean Maçleay Fellow in Geology, Macleay Museum, University of Sydney.

HAMMOND, WALTER L., Science Master, Hurlstone Agricultural Continuation School, Summer Hill.

WHITE, CHARLES JOSIAH, Science Lecturer, Training College, "Patea," Miller Avenue, Ashfield.

The Chairman announced:—

1. That the fifth and last Popular Science Lecture (during this Session) on "Volcanic Action in Australia," by Dr. H. I. JENSEN, would be delivered in the Society's Hall, on Thursday, October 21st, at 8 o'clock.

2. That 30 volumes, 154 parts, 9 reports, 21 pamphlets, and 1 map, total 215 received as Donations since the last meeting were laid upon the table and acknowledged.

The following letter was received from Prof. LIVERSIDGE:

Hornton Cottage, Hornton Street,
Kensington W., 28 July, 1909.

The Hon. Secretaries, The Royal Society of N.S. Wales.

Gentlemen,—I very much regret that owing to the illness and loss of a near relative at the time of the Darwin Memorial Celebration at Cambridge, I was unable to attend to present the address which I had had prepared for the Royal Society of New South Wales. I, however, made arrangements with the Hon. Secretaries for its due presentation. I have forwarded to you copies of the address by post. I am yours truly

A. LIVERSIDGE.

Resolved that the best thanks of the Society be conveyed to Professor LIVERSIDGE for his kindness in dealing with this matter.

DARWIN CENTENARY CELEBRATION 1909.

To the Chancellor and Members of the University of Cambridge.

At the request of the Royal Society of New South Wales, I have the honour to offer the most cordial congratulations and best wishes of its Members to the University of Cambridge upon the occasion of the celebration of the one hundredth anniversary of the birth of CHARLES DARWIN, and the fiftieth anniversary of the publication of the "Origin of Species."

The Royal Society of New South Wales has special pleasure in accepting the invitation to take part in this international gathering to do honour to the work and memory of one of the greatest students of Nature the world has ever known, inasmuch as some of the earliest researches of CHARLES DARWIN in Natural History and Geology were made in New South Wales.

A. LIVERSIDGE, Delegate.

London, June 18th 1909.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on Flour-strength," by F. B. GUTHRIE, F.I.C., F.C.S., and G. W. NORRIS.

Remarks were made by Mr. LOXLEY MEGGITT, Prof. J. A. SCHOFIELD and Dr. H. G. CHAPMAN.

2. "On some Building and Ornamental Stones in New South Wales," by R. T. BAKER F.L.S. and J. NANGLE, F.R.A.S.

Remarks were made by Dr. WOOLNOUGH, Mr. W. J. CLUNIES ROSS, Dr. STOKES, Dr. GREIG-SMITH and the Chairman.

3. On the nature of the Large Ions in the Air," by J. A. POLLOCK, D. Sc., etc.

Abstract of lecture "On Volcanic Action in Australia," (Illustrated by diagrams) by H. I. JENSEN, D.Sc., delivered 21 October, 1909. First the cause of volcanic action, its

commoner phenomena and its effects were dealt with in a general way and illustrated with slides. The eruptions in Samoa in 1902 and 1905-9 were then described. The lecturer explained how viscid lavas give rise to steep cones and often to precipitous monoliths, while fluid lavas give rise to volcanoes with but gently sloping sides. As examples of viscid lavas he mentioned alkaline trachytes and phonolites, and as typical of fluid lavas basalts and certain rhyolites. Scoria cones generally have a higher angle of slope than tuff cones. Fluid lavas are also more apt to give rise to fissure eruptions. The basalts of the Darling Downs of Queensland and Monaro of N.S.W. are probably largely the result of fissure eruptions. Volcanoes are best studied when only in feeble activity, or when quite extinct. It is as hopeless to gain much information from a violently active volcano about its structure as from a machine when all its parts are going at top speed. In Australia we have many extinct volcanoes and dissected remnants of volcanoes. To them we owe our finest scenery and our greatest economic resources. Those which still maintain the perfect cone and crater form are very recent, since volcanic cones are largely made up of easily eroded tuffs and scoriæ. The Tertiary volcanoes are greatly dissected and Pre-Tertiary volcanoes are represented merely by stumps, necks or their plutonic offshoots, such as dykes and laccolites. It is only when Pre-Tertiary lavas have been buried in sedimentary rocks that they remain to tell the tale.

The existence of great volcanic activity in Palæozoic and Mesozoic times is therefore made known chiefly by the granitic and gabbroic deepseated intrusions which were injected into the rocks of the earth's crust simultaneously with the outpouring of lava on the surface. By the study of these masses and the lava flows in the sedimentary series we know that there have in Australia been periods of intense

volcanic activity and periods of comparative quiet. The great volcanic periods correspond with the periods of great disturbance, that is great uplifts over extensive areas and great subsidences in others. Volcanoes in any given region inaugurate a period of uplift, but are accompanied by local subsidences. The volcanic periods in Australia were the Archæan and Precambrian, the Upper Devonian and Lower Carboniferous, the Permo Carboniferous and the Tertiary. The periods of comparative quiet were the Cambrian, Ordovician, Silurian, Lower Devonian, and Upper Carboniferous, the whole of the Mesozoic and the Post Tertiary. The Tertiary period of activity is that of most importance both geographically and economically. Extensive flows of basalt form vast tablelands and plains, and give the most fertile soils of the continent. The earliest Tertiary eruptions were highly alkaline and form an interesting study. The abrupt peaks and gigantic monoliths of the Glass Mountains, Queensland, rising precipitously from a coastal plain, form a wonderful sight. Similar extrusions initiated volcanic activity in the Warrumbungles and Nandewars of N.S.W., but in these districts they were followed by outpourings of more fluid lavas so that a dome shaped mass of lava about 80 miles across was formed in the case of the Warrumbungles and an oval mass in the case of the Nandewars. These were subsequently dissected by erosion. The alkaline rocks follow a line which throughout geological time has been a hinge line in all great earth movements, the continent being alternately east and west of this line.

To the great Carboniferous volcanic period we owe most of our metallic mineral resources. This is well exemplified on the South Coast of N.S. Wales, where the metallic lodes are connected with diorite intrusions, and they occur intruded into all rocks from the Ordovician to the Upper Devonian. No Carboniferous rocks occur, but the over-

lying Permo-Carboniferous is undisturbed and contains no mineral veins. The ore formation therefore occurred in the Carboniferous period. Volcanoes, besides affording us magnificent scenery, are the source of our greatest wealth. Our best soils of great extent are the basaltic, and fortunately basalt was a fluid lava which spread over great areas. To volcanic emanations and volcanic rocks we owe our gem stones, opal, sapphire, ruby and diamond. Our best building stones such as Gib trachyte and Moruya granite are igneous, our best road metal is volcanic basalt, and finally our greatest metal wealth is derived from plutonic emanations accompanying volcanic action.

ABSTRACT OF PROCEEDINGS, NOVEMBER 3, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, November 3rd, 1909.

H. D. WALSH, B.A.I., M. Inst. C.E., President, in the Chair.

Thirty-four members were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. W. A. DIXON and G. HALLIGAN were appointed Scrutineers and Mr. HENRY DEANE deputed to preside at the Ballot Box.

The certificate of one candidate was read for the second time.

The following gentleman was duly elected an ordinary member of the Society:—

LEVERRIER, FRANK, B.A., B.Sc.

Fifteen volumes, 198 parts, 15 reports, 6 pamphlets and 1 map, total 235, received as Donations since the last meeting were laid upon the table and acknowledged.

The President announced the death of the following Honorary Member, viz.:—

Professor SIMON NEWCOMB, Rear-Admiral U.S. Navy, elected 1901, died 11 July, 1909.

THE FOLLOWING PAPERS WERE READ:

1. "Corrasion by Gravity Streams, with application of Ice Flood Hypothesis," by E. C. ANDREWS, B.A.

In the absence of the author, the paper was read by Mr. C. A. SUSSMILCH. Remarks were made by Prof. DAVID.

2. "Notes on the Physiography of the Southern Tableland," by C. A. SUSSMILCH, F.G.S.

Remarks were made by Dr. H. I. JENSEN, and Professor DAVID, to which the author replied.

3. "Note on the occurrence of Manganese in soil and its effect on grass and other crops," by F. B. GUTHRIE, F.I.C., F.C.S., and L. COHEN.

Remarks were made by Mr. R. T. BAKER, Dr. H. I. JENSEN, and Mr. W. A. DIXON.

4. "Observations on the effect of light on the electrical conductivity of Selenium," by O. U. VONWILLER, B.Sc.

Remarks were made by Prof. POLLOCK and Dr. MADSEN.

EXHIBIT.

Mr. L. HARGRAVE exhibited one unit of a flying machine that is automatically stable longitudinally and transversely, also two working models of the same.

ABSTRACT OF PROCEEDINGS, DECEMBER 1, 1909.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, December 1st, 1909.

H. D. WALSH, B.A.I., M. Inst. C.E., President, in the Chair.

Thirty-eight members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

Eleven volumes, 152 parts, 16 reports, 8 pamphlets, and 1 map, total 188, received as Donations since the last meeting, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "Rigid Stable Aeroplanes," by L. HARGRAVE.
2. "Note on the new Wiechert Seismometers at Riverview College, Sydney," by Rev. E. F. PIGOT, B.A., M.B., (with lantern illustrations).

Remarks were made by Prof. POLLOCK, Dr. SPENCER and Dr. WOOLNOUGH. The Rev. E. F. PIGOT replied.

3. "Note on Goulburn Water," by E. J. BURROWS, Caird Scholar, Univ. (Communicated by Prof. SCHOFIELD).

Remarks were made by Dr. STOKES and Mr. W. J. CLUNIES ROSS.

4. "Chemical examination of the oil from the seeds of *Bursaria spinosa* (Blackthorn)," by E. GRIFFITHS, B.Sc. (Communicated by Prof. SCHOFIELD).
5. "On the anatomy of *Monopylidium passerinum*, Fuhrm." by T. HARVEY JOHNSTON, M.A., B.Sc, Assistant Government Microbiologist.
6. "Paper on Lope de Vega," (continued) by L. HARGRAVE.

EXHIBIT:

Mr. T. HARVEY JOHNSTON exhibited a series of entozoa comprising the following:—(1) larvæ of *Gastrophilus nasalis*, Linn., and of (2) *G. equi*, Fabr., both from horses (N.S.W.), the adult bot fly, *G. equi*, being also shown; (3) the larva of the sheep-bot *Oestrus ovis*, Linn., from head sinuses of the sheep (N.S. Wales); (4) *Hypoderma bovis*,

Geer, the "warble," which lives under the skin of the ox; this parasite has not yet established itself in Australia, and is only occasionally met with in imported animals (Sydney); (5) *Demodex folliculorum* var. *suis*, from the hair follicles of the pig (Sydney); (6) Hydatids, *Echinococcus polymorphus*, Dies., from the lung of a wallaby *Macropus ualabatus*, (Gosford, N.S. Wales), this being the first record of the parasite in this host; (7) *Echinorhynchus sp.* from the intestine of a lizard *Lygosoma (Hinulia) quoyi*, (Hawkesbury River, N.S. Wales, collected by Mr. G. P. Darnell-Smith) not previously reported; (8) *Echinorhynchus sp.* from the intestine of a Ludrick fish *Girella simplex* (Bondi, N.S. Wales) not previously recorded; (9) *Myxobolus sp.*, a sporozoan parasite infesting and destroying the genital organs of the frog *Hyla aurea* (Sydney, N.S. Wales); (10) *Davainea australis*, Kr., a cestode from the intestine of the Emu, *Dromaeus novæ-hollandiæ* (N.S. Wales) a parasite not previously recorded from this State.

The following donations were laid upon the table and acknowledged:—

TRANSACTIONS, JOURNALS, REPORTS, &c.

(The Names of Donors are in *Italics*.)

AACHEN—Meteorologische Observatoriums. Ergebnisse der Beobachtungen am Observatorium und dessen Nebenstationen im Jahre 1907, Jahrgang XIII. *The Director.*

ABERDEEN—University. Aberdeen University Studies, Nos. 31, The Miscellany of the New Spalding Club, Vol. II, 1908; No. 35, The Records of Elgin 1234 - 1800, Vol. II, 1908. *The University.*

ACIREALE—R. Accademia di Scienze, Lettere ed Arti degli Zelanti. Rendiconti, Memorie della Classe di Scienze, Serie 3a, Vol. IV, 1904-5; Vol. V, 1906-7. *The Academy.*

ADELAIDE—Department of Intelligence. Bulletin, No. 8, May 1909. *The Department.*

Department of Mines. A Review of Mining Operations in the State of South Australia during the Half-Year ended June 30, 1909, No. 10. ,,

Government Geologist. Reports on Recent Mineral Discoveries, and further record of Northern Territory Boring Operations 1908. ,,

ADELAIDE—*continued.*

Public Library, Museum, and Art Gallery of South Australia. Report of the Board of Governors for 1907-8. *The Director.*

Royal Geographical Society of Australasia. Proceedings of the South Australian Branch, Vol. x, Session 1907-8. *The Society.*

Royal Society of South Australia. Transactions and Report, Vol. xxxii, 1908. „

ALBANY—New York State Education Department. State Library Report, Vol. xc, Parts 1, 2, 3, 1907. State Museum Report, Vol. lxi, Parts 1, 2, 3, 1907. *The Department.*

New York State Museum. Museum Bulletin, 121 – 128, 130, 131, 1908-9. *The Museum.*

ANNAPOLIS, Md.—United States Naval Institute. Proceedings, Vol. xxxiv, Nos. 3, 4, 1908; Vol. xxxv, Nos. 1, 2, 3, 1909. *The Institute.*

AUCKLAND—Auckland Institute and Museum. Annual Report for 1908-9. „

BALTIMORE—Johns Hopkins University. American Chemical Journal, Vol. xl, Nos. 1 – 6, 1908; Vol. xli, Nos. 1 – 6, 1909; Vol. xlii, No. 1, 1909. American Journal of Mathematics, Vol. xxx, Nos. 3, 4, 1908; Vol. xxxi, Nos. 1 – 3, 1909. American Journal of Philology, Vol. xxix, Nos. 3, 4, 1908; Vol. xxx, Nos. 1, 2, 1909. Historical and Political Science, Series xxvi, Nos. 11, 12, 1908; Series xxvii, Nos. 1 – 7, 1909. Johns Hopkins University Circular, New Series, Nos. 8 – 10, 1908, Whole Nos. 209 – 211; New Series Nos. 1 – 7, 1909, Whole Nos 212 – 218. *The University.*

BASEL—Naturforschende Gesellschaft. Verhandlungen, Band xx, Heft 1, 1909. *The Society.*

BATAVIA—Directeur de l'Instruction Publique des Cultes et de l'Industrie aux Indes Néerlandaises. Rapport sur les Moluques, par R. D. M. Verbeek, D. SC., Text and Atlas, 1908. *The Director.*

BERKELEY—University of California. American Archæology and Ethnology, Vol. viii, No. 5, 1909. Botany, Vol. iii, Nos. 6, 7, 8, 1909. Exchanges maintained by the University Press, Jan. 1909. Geology, Vol. v, Nos. 18 – 21, 1909. Physiology, Vol. iii, Nos. 14 – 16, 1909. Publications of the University of California, April 1909. University of California Chronicle, Vol. x, No. 4, 1908; Vol. xi, Nos. 1 – 3, 1909. *The University.*

BERLIN—Gesellschaft für Erdkunde zu Berlin. Zeitschrift, Nos. 8 - 10, 1908; Nos. 1 – 7, 1909. *The Society.*

Königlich Preussische Geodätische Institutes. Veröffentlichung N.F. Nos. 36, 39, 40, 1909. *The Institute.*

Königlich Preussische Meteorologische Instituts. Abhandlungen, Band ii, No. 5, 1904. Veröffentlichungen, Nos. 198, 200 – 207, 1908-9. „

Zentralbureau der Internationalen Erdmessung. Veröffentlichung, N.F. No. 17, 1908. *The Bureau.*

BIRMINGHAM—Birmingham and Midland Institute Scientific Society. Records of Meteorological Observations, 1908. *The Society.*

Birmingham Natural History and Philosophical Society, List of Members 1909, Annual Report for the year 1908. „

BOLOGNA—R. Accademia delle Scienze dell' Istituto di Bologna. Classe di Scienze Fisiche. Memorie, Serie 6, Tomo V, Fasc. 1, 2, 1908. Rendiconto, Nuova Serie, Vol. XII, 1907-8, *The Academy.*

BONN—Naturhistorische Verein der preussischen Rheinlande und Westfalens. Sitzungsberichte, Hälfte 2, 1908. Verhandlungen, Jahrgang LXV, Hälfte 2, 1909. *The Society.*

BOSTON, Mass.—American Academy of Arts and Sciences. Proceedings, Vol. XLIV, Nos. 1 - 25, 1908-9. *The Academy.*

Boston Society of Natural History. Occasional Papers, No. VII, Parts viii, ix, x. Proceedings, Vol. XXXIV, Nos. 1 - 4, 1907 - 9. *The Society.*

BOULDER, Colo.—University of Colorado. Studies, Vol. VI, Nos. 1 – 4, 1908-9. *The University.*

BREMEN—Meteorologische Observatorium. Deutsches Meteorologisches Jahrbuch für 1908, Jahrgang XIX. *The Observatory.*

Naturwissenschaftliche Verein zu Bremen. Abhandlungen, Band XIX, Heft 3 (Schluss) and Beilage 1909. *The Society.*

BRISBANE—Queensland Acclimatisation Society. Annual Report (45th) for Year ended 31 March, 1908. List of some of the plants available for distribution amongst Members and as Exchanges, 1908, „

Queensland Geological Survey. Cloncurry Copper Mining District by Lionel C. Ball, B.E,, Parts 1, 2, 1908. Publication No. 215. Sketch Map of the Herberton and Chillagoe Gold and Mineral Fields, 1909, Publication No. 220. The Etheridge Goldfield (Second Report on) by Walter E. Cameron, B.A., 1909, Publication No. 219. *The Survey.*

Royal Geographical Society of Australasia, Queensland. Queensland Geographical Journal, N.S., Vol. XXIII, 1907-8. *The Society.*

Royal Society of Queensland. Proceedings, Vol. XXII, Part 1, 1909. „

BRISTOL—Bristol Naturalists' Society. Proceedings, Fourth Series, Vol. II, Part 1, 1907. „

BROOKLYN—Brooklyn Institute of Arts and Sciences. Cold Spring Harbor Monographs, No, VII, 1909. Science Bulletin, Vol. I, No. 14, 1908; Vol. I, No. 15, 1909. *The Institute.*

BRUSSELS—Académie Royale des Sciences, des Lettres et des Beaux-Arts. Annuaire, 1909. Bulletin, Nos. 3 – 12, 1908; Nos. 1 - 3, 1909. Notices Biographiques and Bibliographiques re Members etc., 1907 – 1909, 5th edition. *The Academy.*

Observatoire Royal de Belgique. Annales Astronomiques, N.S.. Tome XI, Fasc. 2, 1908. Annales Physique du Globe, N.S., Tome IV, Fasc. 1, 1908. Annuaire Astronomique pour 1909. Annuaire Météorologique pour 1909. *The Observatory.*

BRUSSELS—*continued.*

Société Royale de Botanique de Belgique. Bulletin, Tome XLV, Fasc. 1, 2, 3, 1908. *The Society.*

BUCHAREST—Observatorul Astronomic si Meteorologic din Romanìa. Buletinul Lunar, Anul XVII, 1908; Anul XVIII, 1909. *The Observatory.*

BUFFALO, N.Y.—Buffalo Society of Natural Sciences. Bulletin, Vol. IX, No. 2, 1909. *The Society.*

BUENOS AIRES—Academia Nacional de Ciencias en Cordoba. Boletin, Tomo XVIII, Entrega 3, 1906. *The Academy.*

Museo Nacional de Buenos Aires. Anales, Serie 3, Tomo X. 1909. *The Museum.*

Museo de la Plata. Anales, 2 Ser., Tomo I, Entrega 1, 2, 1907-8. Revista, Tomo XII, Entrega 1, 1905; Tomo XII, Entrega 2, 1906; Tomo XIII, 1906; Tomo XIV, Serie 2, Tomo I, 1907; Tomo XV, Serie 2, Tomo II, 1908. ,,

BULAWAYO—Rhodesia Museum. Annual Report (Seventh) 1908. ,,

CALCUTTA—Asiatic Society of Bengal. Journal and Proceedings, Vol. LXXIV, Parts ii, iii, 1908, Vol. III, Nos. 5-9, 1907; Vol. IV, Nos. 1-4 and Extra No, 1908. *The Society.*

Board of Scientific Advice for India. Annual Reports for the years 1906-7 and 1907-8. Sketch of the Mineral Resources of India by T. H. Holland, D.SC., F.R.S. *The Board.*

Geological Survey of India. Memoirs, Vol. XXXIV, Part 4, 1908. Memoirs, Palæontologia Indica, N.S., Vol. II, Memoir No. 4, 1908; N.S., Vol. III, Memoir No. 3, 1908; Ser. XV, Vol. V, Memoir No. 3, 1908; Ser. XV, Vol. I, Part 1, 1908. Records, Vol. XXXVI, Part 4, 1908; Vol. XXXVII, Parts 1-3, 1908-9. *The Survey.*

The Government of India. A sketch of the Geography and Geology of the Himalaya Mountains and Tibet by Colonel S. G, Burrard, R.E., F.R.S., and H. H. Hayden, B.A., F.G.S., Part iv, The Geology of the Himalaya 1908. *The Government.*

CAMBRIDGE—Cambridge University Library. Report of the Library Syndicate for the year ending Dec. 31, 1908. *The University.*

CAMBRIDGE (Mass.)—Museum of Comparative Zoölogy at Harvard College. Annual Report of the Curator for 1907-8. Bulletin, Vol. XLIII, No. 6, 1908; Vol. LII, Nos. 5-10, 13 1908-9; Vol. LIII, Nos. 1-3, 1908-9. Memoirs, Vol. XXXIV, No. 2, 1908; Vol. XXXVII, 1909; Vol. XXXVIII, No. 1, 1909. *The Museum.*

CAMERON, La.—Gulf Biologic Station. Bulletin, Nos. 8, 9, 10, 1907-8. *The Station.*

CAPE TOWN—Department of Agriculture. Annual Report (13th) of the Geological Commission 1908. *The Department.*

Geological Commission. Geological Map of the Colony of the Cape of Good Hope, Sheet XXXIII, 1908; Sheet XLI, 1909. *The Commission.*

CAPE TOWN—*continued.*

South African Museum. Annals, Vol. VII, Part ii, No. 3. 1908; No. 4, 1909. *The Museum.*

South African Philosophical Society. Transactions, Vol. XVIII, Part iv, 1909. *The Society.*

Royal Society of South Africa. Transactions, Vol. I, Part i, 1909 ,,

CHICAGO—Field Columbian Museum. Geological Series, Vol. III, No. 7, 1908, Publication 129; Vol. IV, No. 1, 1909, Publication 134 Ornithological Series, Vol. I, No. 4, 1909, Publication 135. Report Series—Annual Report of the Director to the Board of Trustees, Publication 133. Zoological Series, Vol. VII, No. 7, 1909, Publication 132. *The Museum.*

University of Chicago Press. Astrophysical Journal, Vol. XXVIII, Nos. 3 – 5, 1908; Vol. XXIX, Nos. 1 – 5; Vol. XXX, Nos. 1, 2, 1909. Journal of Geology, Vol. XVI, Nos. 7, 8, 1908, Vol. XVII, Nos. 1 - 6, 1909. *The University.*

Western Society of Engineers. Journal, Vol. XIII, Nos. 5, 6, 1908; Vol. XIV, Nos. 1 – 4, 1909. *The Society.*

CHRISTIANIA—Videnskabs-Selskabet i Christiania. Forhandlinger, Aar 1908. Skrifter, 1908. ,,

CHRISTCHURCH—Canterbury Museum. Records, Vol. I, No. 2, 1909. *The Museum.*

CINCINNATI—Cincinnati Society of Natural History. Journal, Vol. XXI, No. 1, 1909. *The Society.*

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PROCEEDINGS OF THE GEOLOGICAL SECTION.

(IN ABSTRACT.)

A meeting was held on Wednesday, 18th August, 1909, to resuscitate the Geological Section of the Royal Society, which had been defunct since the year 1891. Mr. R. H. CAMBAGE, Dr. W. G. WOOLNOUGH, Dr. H. I. JENSEN, Dr. C. ANDERSON, Messrs. A. J. WALKOM, L. COTTON, W. S. DUN, and C. A. SÜSSMILCH, were present.

Mr. J. E. CARNE, F.G.S., (Assistant Government Geologist) was elected President, and Mr. C. A. SUSSMILCH, F.G.S., was elected Secretary.

It was decided to meet on the second Wednesday in each month. A general discussion as to the scope of the Section was held, and it was decided that all original geological papers presented to the Society by members should be read at general meetings of the Society, but discussed at the meetings of the Section. It was further arranged that geological papers of special importance from other parts of Australia and abroad, were to be abstracted by members as follows, and the abstracts presented at the monthly meetings of the Section, viz.:—Dr. ANDERSON (Crystallography); E. C. ANDREWS (Physiography); W. N. BENSON (Rock-forming Minerals); L. COTTON (Economic Geology); W. S. DUN (Palæontology); Dr. H. I. JENSEN (Descriptive Petrology); Rev. E. F. PIGOT (Seismology); C. A. SUSSMILCH (Stratigraphical Geology); Dr. W. G. WOOLNOUGH (Optical and Physical Mineralogy).

General Monthly Meeting, 15th September, 1909.

Mr. R. H. CAMBAGE in the Chair.

Twelve members and two visitors were present.

The following order of business for meetings was decided upon

1. Minutes of preceding meeting.
2. Correspondence.
3. Exhibits and notes thereon.
4. Review of Current Literature.
5. Discussions.

Mr. W. S. DUN exhibited fossils collected by Mr. E. C. ANDREWS in the Orange District, including Halysites, Cyathophyllum, Tryplasma, etc.

Dr. C. ANDERSON exhibited rare minerals from various localities.

Mr. C. A. SUSSMILCH exhibited a collection of Alkaline Rocks from the Canobolas Mountains.

The various members present supplied abstracts of current geological literature.

General Monthly Meeting 13th October, 1909.

Mr. J. E. CARNE, in the Chair.

Present fourteen members and one visitor.

Mr. W. S. DUN exhibited a number of N. S. Wales fossils.

Dr. C. ANDERSON exhibited a number of rare minerals.

Rev. E. F. PIGOT exhibited a small meteorite from Queensland.

Mr. C. A. SUSSMILCH exhibited Xenoliths of Gabbro and Peridotite from Kiama, Bulli, The Basin, Bowenfels and Dundas, and made some remarks as to their possible origin etc.

The question of the Section taking up local geological problems for discussion was considered and approved of.

The remainder of the meeting was taken up with abstracts of current literature.

General Monthly Meeting, 11th November, 1909.

Mr. C. HEDLEY, in the Chair.

Ten members were present.

It was decided to hold an Annual Dinner in December in lieu of the ordinary meeting.

The following subjects were submitted for discussion for the ensuing year :—

1. By Prof. T. W. E. DAVID, Control by Atmospheric Circulation of Physical Geography.
2. By W. S. DUN, Age of the Lepidodendron Australe Beds in Australia.
3. By C. A. SUSSMILCH, Physiography of the Blue Mountains.

Mr. E. C. ANDREWS then outlined the main features of his paper on "Stream Corrasion and its application to the Ice Flood Hypothesis." Discussion was postponed pending the printing of the paper.

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